THE BEET GROWERS' MANUAL

AND

TEXT BOOK FOR THE INVESTOR IN : BEET : SUGAR : ENTERPRISES

A COMPLETE SYSTEM OF INSTRUCTION
EMBODYING THE BEST METHODS
HOW TO RAISE SUGAR BEETS
WITH ILLUSTRATED DESCRIPTION OF
BEET FARMING MACHINERY AND IMPLEMENTS

CONDENSED DATA REGARDING THE BEET SUGAR INDUSTRY
HISTORY OF BEET SUGAR IN EUROPE AND THE UNITED STATES
ITS PAST, PRESENT AND FUTURE
HOW SUGAR IS MADE
HINTS HOW TO SECURE, BUILD AND EQUIP A BEET SUGAR FACTORY, ETC.

ALSO A

DIRECTORY

OF

MANUFACTURERS OF SUGAR MACHINERY AND APPARATUS : BEET FARMING TOOLS AND IMPLEMENTS : GROWERS AND DEALERS IN BEET SEED : MANUFACTURERS AND DEALERS IN FERTILIZERS AND CHEMICALS : ETC.

BY
C. W. HAMBURGER
CHICAGO
1901

PRINTED BY
COLUMBIA PRINTING CO.
712 N. HALSTED ST.
CHICAGO

PREFACE.

The growing interest manifested in the development of the Beet Sugar Industry and the rapid strides this new and promising industry has made within the past few years leave no room for doubt that it has come to stay with us.

The permanent establishment of the industry will call for reference books, and "THE BEET GROWER'S MANUAL AND TEXT BOOK FOR THE INVESTOR IN BEET SUGAR ENTERPRISES" was written in the hope that it might prove a valuable help to those on whom the industry depends in the first place, viz: The farmers raising the beets, and the capitalists furnishing the money for the building of factories.

I have divided the book into three parts: The first part being devoted to a brief record of the history of the beet sugar industry in Europe; its rise and progress in the United States and its economic features. The second part deals exclusively with beet culture. While beet raising has not come to us as an untried experiment, it is an entirely new interprise for most of our farmers. To make a success of it, it is necessary that every factor entering into it be given careful consideration and attention. I have endeavored to give under this heading what I consider the most practical and accurate methods for raising beets, avoiding detail of a too scientific nature, the book being primarily intended for the novice in the field. However, I trust that it will also prove of interest to the experienced beet farmer, agriculturists and factory owners.

Part three contains a short description of the process of Sugar making, hints how to secure and build a sugar factory and other information of interest to the investor in beet sugar enterprises.

The datas are from many sources, the principal ones being publications by the U. S. Department of Agriculture and State Experiment Stations, The Weekly Statistical Sugar Trade Journal, and others. As is to be expected in a compilation of data of this character from miscellaneous sources, the figures presented do not always fully agree, but in no instance is there a serious discrepancy.

The Appendix contains a Directory, the object of which is to furnish the very best sources for purchasing sugar and other machinery, beetfarming tools and other articles and materials used in field and factory.

CHICAGO, January 1901.

C. W. HAMBURGER.

PART I.

History of Beet Sugar in Europe. Rise and Progress of the Beet Sugar Industry in the United States.

INTRODUCTORY.

The growth of the Beet Sugar Industry during the last decade, particularly during the last couple of years, is one of the wonders that have astounded the agricultural and commercial world on both sides of the ocean. At the beginning of the decade less than 2500 acres of sugar beets were raised, while to-day 100,000 acres are devoted to sugar beet culture.

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 this prophesy shall become true rests with the American farmer, and I 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 comsumption 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 certain extent by a more intense system of farming, such as growing sugar beets for the production of sugar.

In view of these conditions and considering that no other country on earth is more favored by its natural resources to produce one of the most important articles of daily consumption, it must be regarded as peculiarly proper that public attention is turning more and more seriously toward the question, whether with intelligent management the raising of sugar beets and the production of sugar therefrom can be made a fixed feature in our agricultural and industrial systems, as it has become in many countries in Europe.

In Europe to-day sugar beet raising and beet sugar manufacture is a decided success. In Germany, Austria, France especially the cultivation of sugar beets has produced an enormous boom and developed into gigantic dimensions.

The highly prosperous condition of the farmers in the beet sugar producing districts in Europe is the most convincing proof of the beneficial consequences which followed the introduction of beet culture everywhere.

Whatever difference of opinion there may have existed at various times regarding the feasibility of establishing the industry as a mere industrial enterprise, there can be no doubt that sugar beet culture has always proven an invigorating stimulant to agriculture, introducing sound principles into agricultural methods and pursuits, a more rational, practical and scientific rotation of crops, thereby increasing crops of all kinds and producing larger quantities of fodder and meat. But it has also brought about and promoted a healthy feeling of mutual interest between farmer and manufacturer, between capital and labor.

European agriculturists, however, only accomplished this union of industrial and agricultural interests by devoting themselves with almost unrivaled perseverance to the task of producing a sugar beet of the highest standard of quality, containing the largest possible amount of sugar in the most favorable condition of extraction.

It is no longer a problem whether beet sugar manufacture can succeed in this country, and the question, is there money in beet raising and sugar making, has been answered in no uncertain manner by the results which were produced through the introduction of the industry in such localities as have now sugar factories.

Since the history of the industry in Europe offers so many points of comparison and in many instances represents the exact counterpart of the various stages of development in this country, I have thought it advisable to preface the subject proper by a short synopsis of the history of the industry in Europe.

HISTORY OF BEET SUGAR IN EUROPE.

On the 11th of January, 1899, 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 into a most wonderful industrial power. More correctly the birth of the beet sugar industry dates back to the year 1747, when the German chemist Margraf published the results of his investigations regarding the availability of certain beet varieties as sugar producers. He produced sugar from beets in a limited way by laboratory experiments. However, his work did not lead to any practical results and the matter lay dormant for half a century. It was left to Franz Carl Achard, Director of the Royal Prussian Academy of Sciences, and a pupil of Margraf, 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 be justly called the father of the 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 presents magnitude. Achard's report resulted in a government order that beets should be raised in large quantities in all provinces, and the establishment in 1799 of the first beet sugar factory at Kunern, 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. At Achard's time one pound of sugar cost from $1.50 to $2.00. Still Achard's efforts might have proved fruitless, as the cost of production was considerably in excess of the price of the sugar, had it not been for Napoleon I.

NAPOLEON I.'S INTEREST IN BEET SUGAR.

In order to cripple and destroy English commerce Napoleon ordered and maintained a blockade of continental ports against English colonial products. European ocean traffic was thus interrupted, that sugar cargoes reached their destination only at great hazards. Sugar prices advanced exhorbitantly, which gave a fresh stimulus to the erection of additional factories in Saxony, Silesia, Bohemia, Austria and especially in Belgium and France. On March 25th, 1811, Napoleon issued his first decree for the encouragement of the beet sugar industry, setting aside lands for the culture of beets and establishing schools for the study of beet sugar chemistry, appropriating $200,000 for this work. Further decrees carried additional subsidies and by their aid the beet sugar industry made rapid strides both in Germany and in France. The success of the continental factories and their threatening competition with colonial sugar, England's monopoly, spread great alarm among 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 large scale had convinced him that beet sugar could never replace cane sugar. They are said to have offered him at first 50,000 Thalers, and later on 200,000 Thalers, but he refused to retract. Neither threats, blandishments nor bribes availed with him. The English importers, aided by the English colonial office, left nothing untried in their efforts to kill the industry in the bud. But all their intrigues were unsuccessful. They went thus 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 be encouraged, and justly so, by Achard's example?

Altough in very slow stages, the beet sugar industry worked ahead. In the early days the product amounted to but 2 to 3 per cent. of the original weight of the beets, but the factories soon stood on a paying basis, owing to the high price of the product. 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 sugar, became less prosperous, in fact, most of the sugar factories in Germany were ruined.

TEMPORARY DECLINE OF THE INDUSTRY IN GERMANY.

Colonial sugars, under a heavy and constantly increasing influx of shipments from the tropics, became cheaper and cheaper, and notwithstanding the improvement in the chemical, technical and mechanical branches of the beet sugar manufacture, the return was still so limited that the German beet sugar manufacturers were unable to cope with the colonial competitor. They lost money, and as a consequence many factories closed down for good.

FRANCE, THE CHIEF NURSERY OF THE INDUSTRY FROM 1812 TO 1835.

In France, partly owing to improved methods of manufacture devised by French chemists, and partly as a consequense of the natural 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 industry. In 1828 there were already 103 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 2 to 3 per cent. as much as 5 and 6 per cent. was obtained, and the production of beet sugar rapidly increased, amounting to about 40,000 tons in 1835.

FRESH IMPETUS TO THE INDUSTRY IN GERMANY.

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 Quedlinburg for the purpose of building and starting sugar factories on a paying basis. This trio of promoters 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 success. But this was not so much the fault of these early promoters of beet sugar enterprises, as owing to the fact that the chief principles of beet culture and the art of sugar-making were 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 saccharometer 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 industry, the chemist Franz Schatten, 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 sugar content by titration with acids. Of course, his apparatus is no longer in use, but in his time it was a great boom 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 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.

GERMANY TAKES THE LEAD AS BEET SUGAR PRODUCER.

At the beginning of the forties Schatten and such men as Marker, Balling, Ring, Robert—who in 1837 built a factory at Gross-Sedowitz where he introduced the Robert evaporators and numerous other improvements in manufacture—, Schulz, Schuetzenbach and others, by scientific researches and practical experiments had demonstrated the fact that from properly cultivated beets 6 to 8 per cent. refined sugar were obtainable. Schuetzenbach built in 1839 a factory at Waghäufel, in Baden, where he devised many improvements and where from that time on nearly all important inventions were tested. His sugar boxes, first brought out in 1841, are still in use in many factories.

The high protective tariff which 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 and the active interest by beet growers' and sugar manufacturers' associations, which were formed at that time and were very instrumental in improving field and factory work by the discussion of methods, new processes and inventions, and an interchange of opinions and experiences, within comparatively short time the industry assumed larger proportions until it became one of the most potent factors among 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. Tons.	AVERAGE WORKED PER FACTORY. 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 19 per cent., the quantity of beets worked increased 178.1 per cent. At the beginning of said period each factory worked up 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.

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.

The same official source gives the following data:

WORKING SEASON.	NUMBER OF FACTORIES.	QUANTITY OF BEETS WORKED. Tons.	AVERAGE WORKED PER FACTORY. Tons.
1895-96	397	10,589,413	26,673
1896-97	399	13,721,601	34,390
1897-98	402	13,697,891	34,074

Secretary Wilson's report on the "Progress of the Beet Sugar Industry in the U. S. in 1899" (Hdoc. No. 699, 56th Cong., 1st Sess.) contains the following tables which furnish a lucid exposition of the industry's progress in Germany for the last 22 years.

STATISTICS OF BEET SUGAR INDUSTRY IN GERMANY 1877 TO 1899.

I.

YEAR.	Area Cultivated.	Beets harvested per Acre.	Value of Beets per Acre.	Average Price of Beets per Ton.	Beets Worked.	Total Production of Raw Sugar.	Beets required for one ton of Raw Sugar.
	ACRES.	TONS.	DOLLARS.	DOLLARS.	TONS.	TONS.	TONS.
1877–78	258,809	11,088	55.45	5.00	4,090,968	378,009	10.82
1878–79	266,075	11,696	62.48	5.00	4,628,748	426,155	10.86
1879–80	279,230	10,199	55.57	4.85	4,805,262	409,415	11.74
1880–81	292,574	13,234	67.49	4.60	6,322,203	555,915	11.37
1881–82	299,624	11,453	61.28	5.40	6,271,948	599,722	10.46
1882–83	319,406	13,922	73.19	5.30	8,747,154	831,995	11.51
1883–84	347,924	12,100	63.83	5.30	8,918,120	940,109	9.49
1884–85	370,840	13,314	52.59	4 00	10,402,688	1,123,030	9.26
1885–86	343,145	12,221	46.44	3.80	7,070,316	808,105	8.75
1886–87	365,169	12,141	43.24	4 60	8,306,671	985,628	8.43
1887–88	651,815	10,684	49.68	4.70	6,963,961	910,698	7.65
1888–89	691,897	11,412	54.78	4.30	7,896,163	944,505	8.36
1889–90	752,259	13,314	61.25	4 60	9,822,635	1,213,689	8.09
1890–91	825,825	13,031	63.86	4.70	10,623,319	1,284,485	8.27
1891–92	861,583	11,412	54.21	4.80	9,488,002	1,144,368	8.29
1892–93	869,829	11,291	54.20	5.00	9,811,940	1,171,843	8.37
1893–94	954,995	11,125	55.65	4.80	10,644,952	1,316,665	8.10
1894–95	1,090,809	13,273	63.71	4.80	14,521,030	1,766,805	8.23
1895–96	930,749	12,546	51.44	4.10	11,672,816	1,537,522	7.63
1896–97	1,049,881	13,072	53.60	4.10	13,721,601	1,738,885	7.09
1897–98	1,079,810	8,619	50.48	4.00	13,697,892	1,755,229	7.08
1898–99	1,054,229	11,519	.....	.....	12,144,291	1,710,000	7.01

II.

YEAR.	Sugar in the Beet.	Mean prices per pound		Raw Sugar from 1 ton of beets.	Export Bounties Paid.	Export to United States.
		Raw Sugar.	Refined Sugar.			
	PER CENT.	CENTS.	CENTS.	POUNDS.	DOLLARS.	TONS.
1877–78	9.24	6.26	8.08	203.07	4,249,531	......
1878–79	9.21	6.01	8.37	203.04	6,035,673	......
1879–80	8.52	7.44	9.28	187.83	5,745 652	......
1880–81	8.79	6.69	8.74	191.08	13,458,421	......
1881–82	9.56	6.69	8.85	210.75	10,332,190	......
1882–83	9.51	6.46	8.15	209.66	17,706,645	......
1883–84	10.54	5.66	7.66	232.36	22,919,935	......
1884–85	10.79	3.93	5.61	237.88	30,571,744	......
1885–86	11.43	5.08	6.53	251.99	21,436,084	......
1886–87	11.87	4.11	7.72	261.69	25,899,398	......
1887–88	13.08	5.18	6.48	288.36	25,125,184	} 11.426
1888–89	11.96	3.78	6.21	263.67	19,058,088	
1889–90	12.36	3.23	6.05	272.49	14,746,480	35,420
1890–91	12.09	3.45	5.88	266.53	18,648,728	140,293
1891–92	12.06	3.99	6.42	265.87	17,757,418	34,358
1892–93	11.94	3.02	5.88	263.23	8,199,338	113,319
1893–94	12.34	2.72	5.72	272.47	2,713,438	115,698
1894–95	12.15	1.84	4.48	267.86	3,576,044	134,128
1895–96	13.11	2.38	4.97	286.82	4,380,866	193,932
1896–97	12.66	2.14	5.04	279.01	6,083,756	500,139
1897–98	12.79	2.18	5.04	281.97	8,724,842	142,907
1898–99	13.15	2.25	5.13	310.42	....	......

These tables show several interesting facts, the most important of which, the increase in the yield of sugar, owing, of course, to the improved methods of beet culture, resulting in production of beets of higher sugar content, and the improvement in the process of sugar manufacture, enabling the manufacturer to extract a larger percentage of the sugar contained in the beet. In 1877-78 the total production of raw sugar amounted to 378,009 tons; in the campaign 1898–99 to 1,710,000 tons, or four and one-half times the former amount. At the beginning of the stated period 10.82 tons of beets were required to produce a ton of sugar, while in 1898–99 only 7.1 tons of beets were required. In commenting on these tables, Chas F. Saylor, Special Agent of Department of Agriculture, and author of the government report referred to, states:

> "The decrease in the amount of beets required for a ton of sugar and increase of the amount of sugar in the beets, gradual in both cases, and decidedly marked in the extremes, illustrates very clearly the advantage of experience both to manufacturing and sugar beet growing, and is due to two causes: First, better methods of manufacture by which the factory is able to extract from the beet more of its sugar content; and second, careful breeding and selecting of seed by which beets of high sugar content have been developed, and better methods of agriculture, by which the farmer is able to produce beets of better quality. This illustrates the point for which I have been contenting throughout this report, namely, that when the factories and the farmers through experience shall have been able to discover and adopt the best methods, the cost of sugar production will gradually become less, as it has in every other country. It will be noticed in this connection, as a natural consequence that the amount of sugar received from a ton of beets has increased about one-third, while the price of sugar beets has gradually gone down. At the same time it will be noticed that the selling price of raw and refined sugar has decreased in a more marked degree."

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 beet sugar production of 5,300,000 tons, the latter representing two-thirds of all the sugar production in the world. Germany alone produces the amount equal to present total annual imports of sugar into the U. S.

Other European beet raising countries show a similiar rapid progress. A full statistical exhibit, while of interest, would transgress the scope of these pages, and I therefore confine myself to giving a few of the most important datas, touching on beet sugar production in the five beet sugar producing countries of Europe, ranking next to Germany, for the five seasons 1893–94 to 1897–98:

YEAR.	Factories in Operation.	Area Cultivated. HECTARES.	Beets Worked. TONS.	Production Based on Raw Sugar. TONS.	Sugar in Beet. PER CENT.	Sugar Exported. TONS.
		AUSTRIA-HUNGARY.				
1893-94	216	350,400	6,401,200	834,000	13.03	490,100
1894-95	220	376,160	8,530,000	1,044,600	12.25	452,900
1895-96	218	288,900	5,760,000	781,500	13.55	504,600
1896-97	217	349,700	7,866,000	930,000	11.82	565,200
1897-98	216	302,100	6,865,400	821,800	11.97	493,500
Average..	217	333,452	7,084,520	882,380	12.52	501,260
			FRANCE.			
1893-94	370	220,010	5,250,193	540,000	10.28	284,174
1894-95	367	241,524	7,137,737	745,073	10.44	333,096
1895-96	356	204,718	5,411,484	624,869	11.55	248,388
1896-97	358	246,204	6,765,000	703,300	10.40	360,098
1897-98	344	228,479	6,401,890	773,156	12.08	463,672
Average..	359	228,187	6,193,261	677,278	10.95	337,885
			RUSSIA.			
1893-94	225	325,893	5,648,595	642,783	11.38	84,439
1894-95	226	334,188	5,406,000	597,044	11.04	85,472
1895-96	229	345,042	5,502,700	754,968	13.72	181,454
1896-97	234	358,537	5,732,000	706,212	12.32	114,748
1897-98	238	406,957	6,100,000	740,000	12.13	142,023
Average..	230	354,123	5,677,859	688,201	12.12	121,627
			BELGIUM.			
1893-94	121	69,000	1,883,000	226,400	12.02	182,900
1894-95	122	71,235	2,278,000	250,800	11.01	121,063
1895-96	123	58,588	1,766,000	220,000	12.46	179,776
1896-97	123	71,275	2,330,000	280,000	12.01	216,880
1897-98	124	55,300	1,796,000	234,000	13.03	179,491
Average .	123	65,080	2,010,600	242,240	12.10	176,022
			HOLLAND.			
1893-94	30	33,000	623,000	74,293	11.92	133,700
1894-95	30	33,917	694,000	85,310	12.29	133,650
1895-96	30	32,764	818,000	98,210	12.01	160,008
1896-97	30	44,387	1,276,000	172,083	13 41	176,455
1897-98	31	35,789	890,240	125,658	13.70	150,040
Average..	30	37,971	860,248	111,110	12.67	150,770

From these figures the observant reader may form some conclusions as to what the industry will amount to in the United States when 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 sacrifice by the government and private individuals it is now able to pay $33,000,000 annually in taxes to the state. Large as this sum may appear, it is nothing compared to the wealth the industry has brought to the nation.

In concluding this short review of the history of beet sugar in the Old World, mention must be made that the industry is now making rapid progress in many countries where it has been newly introduced. In Spain, the beet sugar industry has developed with great rapidity during the last few years, likewise in Sweden. Bulgaria, Servia, Roumania, Italy, Switzerland and Greece are emulating the example set by other nations of Europe, and considerable attention is being paid to beet culture, and efforts are being made to establish the beet sugar industry in Egypt, Persia and Chili.

HISTORY OF THE INDUSTRY IN THE UNITED STATES.

The first beginnings in raising and cultivating sugar beets in this country date back into the thirties of last century, just the time when the industry, which up till then, as related in the preceeding pages, had been struggling along slowly in most of the European beet raising countries, underwent there a strong revival. In Germany, Belgium and Austria many new factories were started, and in France particularly, which at that time, as already mentioned, was the chief nursery of the industry, through Dubrunfant, Biot and other celebrated chemists numerous improvements resulting in simplifying and improving the process of manufacture and increasing the percentage of refined sugar originally obtained from the beets, were introduced in the existing factories.

No doubt the increased attention and the growing success of the industry in Europe induced the first attempts in beet culture and the manufacture of beet sugar in this country. To the Society of Shakers at Ensfield, near Philadelphia, and to John Massey in Illinois belongs the credit of having first introduced beet culture in the United States. Their efforts, however, were limited in the main to the raising of beets, and up to 1837 manufacture of sugar was attempted only in an experimental way, without leading to practical results. In 1838 Dav. L. Child, who in 1840 published a book on the culture of beets and the manufacture of beet sugar, organized the Northampton Beet Sugar Company, at Northampton, Mass., and located a factory in the state of Connecticut. His method consisted in drying the beets and then extracting the sugar therefrom. It was not a brilliant success, and only about 1300 pounds of sugar were made in this way, at an estimated cost of 11 cents per pound. He extracted from the beets 6 per cent. of sugar and 2½ per cent. of molasses, and made the cost of culture $42.00 per acre, with an average yield of 13 to 15 tons of beets.

There was then an interim until 1863 when two Germans, the Gennert Brothers, experts from Brunswick, Germany, established a factory at Chatsworth, Ill., 100 miles south of Chicago, under the name of the Germania Beet Sugar Co. Machinery for the plant was imported from Europe, upon which a heavy duty was paid. The factory had about 10,000 acres under cultivation, and during the early years 3¼ per cent. of sugar was obtained, and later under new management the amount increased to 5½ per cent. Outside of the small percentage of sugar obtained from the beets at the start, a number of causes, such as bad culture in 1868, deluging rains in 1869, drought in 1870, and generally a lack of sufficient labor at the right time, contributed to the failure of the enterprise, which, however, was doomed from the beginning, as the location was badly chosen. In the first place the soil was ill adapted for beet culture; secondly, unfavorable climatic conditions and particularly scarcity of water proved a serious obstacle to success, and after struggling along for six years the undertaking collapsed. In 1871 the plant was removed to Freeport, Ill., where the soil was better, but other conditions were just as unfavorable, so that at the end of the year the Germania Beet Sugar Co went out of existence, having sunk, it is said, about $300,000 in the attempt to establish the industry. The Gennert Brothers in 1870 started another plant at Black Hawk, Wis., but it failed also, owing to the fact that the farmers did not raise beets in sufficient quantities to keep the factory properly supplied. From Black Hawk part of the machinery was removed to California. Thus the industry during the first forty years of its history in this country proved a complete failure.

The first successful undertaking was that by Bonesteel & Otto, two German experts who about 1868 organized a company with a capital of $12,000, which operated a small factory at Fond du Lac, Wis.

In 1869 Bonesteel & Otto with others organized the California Beet Sugar Co., capitalized at $250,000. The factory was built in 1870, at Alvarado, with machinery from the dismantled Illinois and Wisconsin factories, and Bonesteel & Otto took charge of the new factory, abandoning their works at Fond du Lac.

Subsequently Mr. Otto went to Santa Cruz County, Cal., where he operated a factory until 1876. The Alvarado company failed in that year but was reorganized in 1879 and has been in continued operation ever since.

Various efforts during the late 70's to establish the industry in the states of Delaware, Maine, Massachusetts and New Jersey proved also unsuccessful. In 1876-77 Delaware appropriated money for premiums amounting in the two years to $1800. The result was the establishment of a sugar factory at Wilmington, which, however, proved a financial loss. The company which was organized April 1, 1879, under the name of The Delaware Beet Sugar ManufacturingCo., had amongst its directors some of the most influential men of the state. As stated in a Wilmington paper, the directors did not deem it necessary to built their factory, until the first crop of beets was raised. It was further stated that the company intended manufacturing sugar from dried beets, using only such green beets as might be grown contiguous to the factory. It is certainly not to be wondered at that the enterprise turned out a failure.

In 1870 the Massachusetts legislature exempted from taxation for ten years all capital and property engaged in the beet sugar industry, and subsequently granted a bounty of 1 cent per pound on all sugar produced. The Franklin Sugar Refining Co. was organized in 1879 at Franklin, Mass., with $75,000 capital, and it furnished seed to the farmers under contract to cultivate a certain number of acres. The farmers paid but little attention to the culture, and what beets they did raise, were worth more for feeding to cattle than the factory could afford to pay: consequently in a short time the company failed.

The state legislature of Maine in 1877 offered a bounty of 1 cent per pound for the manufacture of sugar from beets grown in the state, the amount so paid not to exceed $7000 in one year, and the bounty not to extend beyond a term of ten years. The Forrest City Sugar Refining Works in Portland, Me., were adapted to beet sugar making by the addition of machinery imported from Germany, and the Maine Beet Sugar Company was incorporated in 1877. In the first year, which was largely experimental, some 180,000 pounds of sugar and melada were made. About 1700 farmers became engaged in beet culture, and nearly 1200 acres were planted. The beets yielded an average of 10 per cent. of sugar to the ton. The factory worked up 120 to 150 tons of beets daily and produced beet melada and raw sugar of good quality which was sold to sugar refineries. In 65 working days about 9000 tons of beets were worked into 900 tons of sugar and melada, which sold for over $100,000. There was a small profit in the business in 1879, but no dividends. However, the industry was quickly abandoned in Maine, as the supply of beets was too small.

It is rather singular, that the aforementioned four states should have been chosen for the early attempts to establish the industry, as their climatic and soil conditions, not to speak of other reasons, offered no particular inducement for beet raising. Yet it is to be remembered that comparatively little was known at that time in regard to the requirements for successful beet culture. It was only in 1879 that Lewis S. Ware founded "The Sugar Beet" in Philadelphia. Too much credit cannot be given to Mr. Ware for his efforts to establish the industry in this country. Another name linked with the early efforts of establishing the industry in this country deserves to be mentioned here, namely that of Dr. Chas. H. Goessmann a German sugar expert, from 1871 to 1876 a member of the faculty of the Massachusetts Agricultural College, Amherst, Mass., who conducted the first scientific experiments in sugar beet culture. In the annual report of the college, of 1872, he said cetera ceteribus :

"The great interest which of late has been manifested throughout the entire country in regard to the introduction of the beet sugar manufacture is a sufficient proof that its importance begins to be realized. The question has reached in the minds of many already a state which leaves no further choice for argument, than the laboratory, the field and the factory. We have in many respects an easier task and less discouraging prospects than those who began this enterprise years ago in Europe, when contemplating the introduction of the beet sugar manufacture. They had first to find out how to raise a good sugar beet and how to separate the sugar in an economical way, while we may simply follow their teachings for the present, ascertain the result upon our soil, and modify our methods to suit our circumstances. *They were not less confronted in their time by the same difficulties, which are held up to us as great obstacles in the way of success, namely: an uncertain degree of protection for a struggling home industry and too expensive labor by hand to compete with the colonial sugar produce of the West and East Indies.* Their times were indeed hard and their chances frequently doubtful; yet in looking closer at their struggle, we cannot help noticing that the very circumstances which seemed at times to render success impossible, have contributed largely to a final good result."

In a footnote the author stated in support of the foregoing :

"From 1836 to 1848 about 2000 lbs. of the beet roots were required to produce 100 pounds of sugar (= 5 per cent.); from 1846 to 1856 about 1500 pounds of beet roots to produce 100 lbs. of sugar (= 6⅔ per cent.); from 1856 to 1868 about 1250 pounds of beet roots for 100 lbs. of sugar (= 8 per cent.)"

The report goes on as follows:

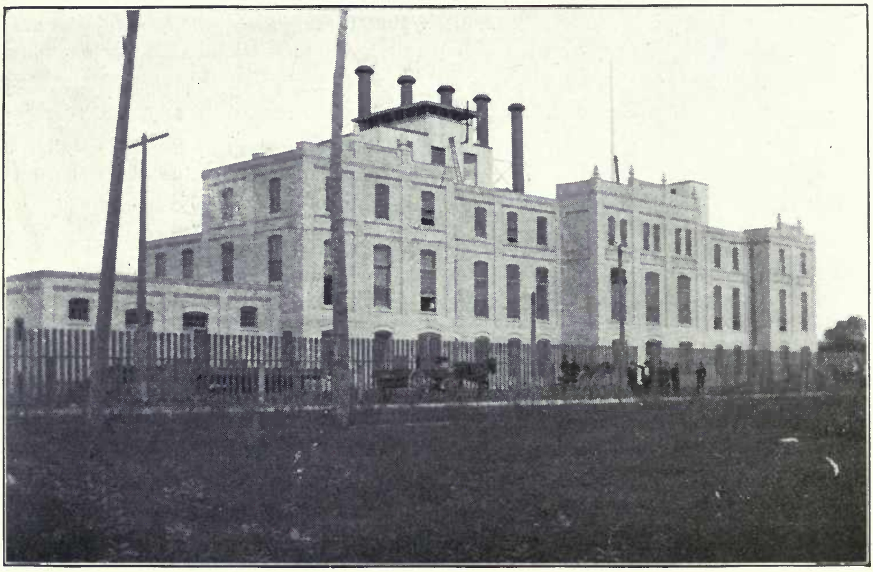
"A firm belief in the advantages offered by a rational mode of cultivation and by skilled labor over mere empirical routine carried them successfully to the end. How well they succeeded may be inferred from the following two facts: First, most of the sugar refineries which in former years were engaged in refining sugar from sugar cane of the Tropics, are now refining home-made beet sugar. Secondly, the introduction of numerous mechanical contrivances has reduced expensive hand-labor in the field and in the factory to a condition which compares favorably with the relative machine and hand-labor employed in similar industrial operations.........The interests of the Louisiana sugar planters and the sugar beet cultivators of more northern sections of the country are the same as far as a proper protection of their industry is concerned.........*The real success of the beet sugar industry in its present high stage of development, depends with us in my opinion far more on an intelligent and close attention to the details of its various operations in the field and in the factory, than on any other requirements.*"

In the quotations given the *italics* are my own. There is hardly a sentence in the above cited utterances of Dr. Goessmann, at the time named that is not fully applicable to-day. The whole report was a masterly plea for the introduction of the industry, and if his words had been heeded, the industry, no doubt, would have reached its present stage much sooner. It was possible even at that day to understand how extensive the development of the industry would be, but there were few who realized its possibilities.

CAUSES OF THE EARLY FAILURES OF THE INDUSTRY IN THE UNITED STATES.

The principal cause or causes, for there were many to which these early failures above referred to were attributable, were in the first place, careless and haphazard methods in field and factory work. But the indolence, the ignorance and the inattention of the farmers, and their consequent inability or unwillingness to supply the then existing factories with the necessary amount of beets of workable quality, was undoubtedly the main cause.

Next to the unwillingness or inability of the farmers to furnish a full and regular supply of properly grown beets, careless and inexpert



MICHIGAN SUGAR CO.'S FACTORY, BAY CITY, MICH.
First Beet Sugar Factory erected in the State of Michigan.—Front View.

factory management must be set down as a cause for the failure of all the early enterprises, and last but not least the lack of capital.

Even as late as 1878 it was generally believed and publicly stated that the simple apparatus used in the manufacture of cider and in making sugar from maple sap, was sufficient for making sugar from beets. Bulletin No. 61 of the Maryland Agric. Experiment Station quotes some amusing illustrations of the popular ignorance which prevailed in regard to beet sugar manufacture. It quotes from a letter published in the *Maryland Farmer* of December 1878, written by McAndrew H. Ward, as follows:

"The beet juice is boiled down the same as maple sap, sorghum or cane juice, requiring no more labor or skill, and can be done as economically on the above quantity (725 bushels) as on a large amount. It needs no costly machinery, such as centrifugals, hydraulic presses, vacuum pans, or filtration through bone coal, etc.........The present cider mills and cheese factories could add to their present machinery the pans or presses, as required, and by co-operation on this, as in regard to other products, we can produce profitably all the sugar we need.

The same writer is quoted as giving the cost of a sugar factory capable of working 30 tons of beets per day as $3500 and as estimating that such a factory would produce in a season 480,000 pounds of sugar.

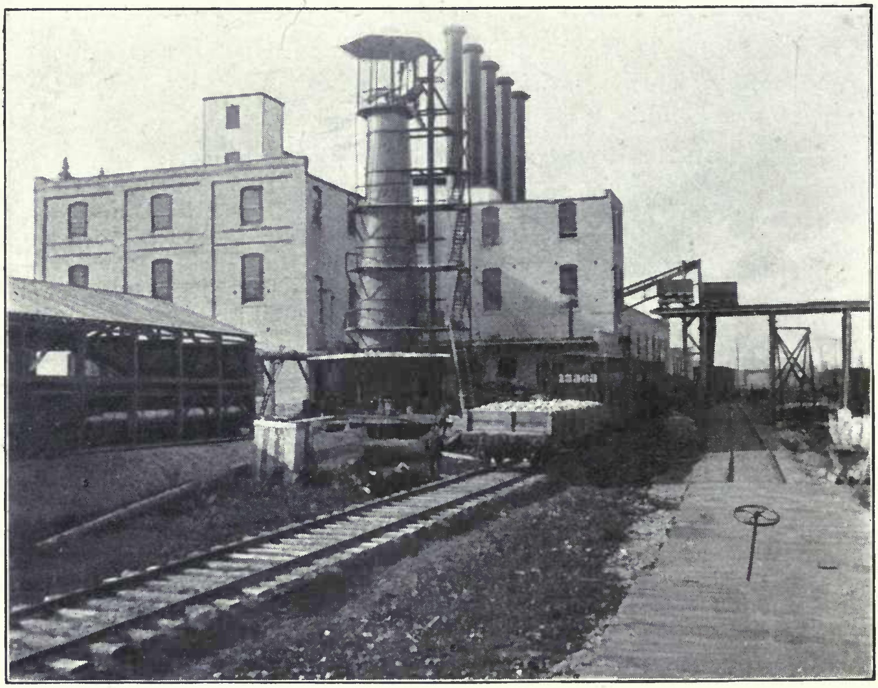
The aforementioned Bulletin states further: "It is evident from the literature of the time that the prevailing opinion in regard to the industry was, that the beets should be sliced and dried before shipment to the factory. This is shown by an article in the *Baltimore Sun*, copied in the *Maryland Farmer* for July 1879, as follows:

It is wonderful that the old clumsy chemistry of raw beets is not universally abandoned. Hereafter instead of raw beets full of bitterness and with only 8 per cent. of sugar, our mills will use dried beets, yielding 50 per cent. of sugar. Instead of costing 7 cents a pound to make sugar, half that sum will cover the cost. Instead of our mills working at most three and a half months of the year, they can be kept busy for twelve months. Instead of being dependent upon the vicissitudes of the weather for every year's crop, a supply can be held in stock for two years ahead Baltimore may yet be destined to outrank New Orleans as a market for sugar."

Before continuing the history of the industry in the United States, I must briefly refer to the efforts which were made at about the same time in the Dominion of Canada to establish the industry there. Notwithstanding the fact that the Canadian Government encouraged this industry by a direct subsidy, the factories established in the beginning of the 80's at Farnham and at Berthierville in the province of Quebec, proved financial failures. The Berthierville plant was removed to Eddy, New Mexico, in 1896, and the Farnham plant in the year following to Rome, N. Y. The same causes which led to the failures in the United States, viz: lack of capital, indisposition of the farmers to raise beets, and mismanagement of the factories brought about the same result in Canada.

But to return to the history of the industry in this country: About the year 1879, interest in the beet sugar industry became more general throughout the United States. This was largely due to the persistent efforts in arousing interest and systematic investigations made by the Departement of Agriculture under the direction of Dr. William McMurtrie, and his successor as chief of the Department of Chemistry, Prof. H. W. Wiley. The former was the author of a most interesting and valuable report on beet culture which was published by the department in 1879.

To the persistent, untiring, one might almost say obstinate efforts of Dr. Wiley, whose name is inseparably connected with the industry more than to any other person living, the present promising state of the industry is to be attributed. Under his efficient management much was done, and is being done at this present time to promote the value of experimental station and government work in connection with beet culture. With a singleness of purpose and a devotion unparalleled he has pleaded with word and pen the cause of the industry for the last quarter of a century. His numerous writings and the government



MICHIGAN SUGAR CO.'S FACTORY, BAY CITY, MICH.
Rear View.—Showing Lime Kiln.

reports published under his supervision, giving the results of much painstaking and earnest work spread the gospel of this new industry. Yet it was a long time before the voice of this apostle of the industry was heeded.

It seems surprising that with the example set us by the older countries and their experience covering 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. But as we have seen, such is the record. However, these failures, like similar failures in most any new field or untried industry were elements essential to the ultimate success. They furnished knowledge. As the beacon of the lighthouse warns the navigator of the seas of dangers ahead, they disclosed to those who afterwards embarked in the industry the "rocks ahead" to success.

Taking up again the historical thread we have to chronicle the reorganization in 1879 of the Alvarado factory, which had failed in 1876. Mr. E. H. Dyer, on whose property the plant was first located, bought the buildings and outfit and a portion of the land of the old company, and in 1879 organized the Standard Sugar Mfg. Co. with a capital of $100,000, which was afterward increased to $200,000 and the name of the company changed to the Standard Sugar Refinery. It was again reorganized and the name changed to the Alameda Sugar Co., the name it still bears.

PROGRESS OF THE INDUSTRY. 1890-1897.

The success of this factory, — which may justly claim the title of the pioneer of the industry —, in the face of a number of adverse conditions, and exposed to direct competition with the cheap product of plantation labor, imported free of duty from the Hawaiian Islands under the provision of the then existing treaty, offered a striking proof of the vitality of the industry. It kept alive the spark of interest, which in our days has kindled into a mighty flame.

Up to 1890 practically nothing was done and the question of raising beets and manufacturing sugar therefrom almost dropped out of sight completely. About this time the Oxnard Brothers, practical sugar men from the East, who had sold their Eastern Refinery to the Sugar Trust, and who had spend several months in Europe looking up the beet sugar industry there, came to the Pacific Coast and established first a factory at Chino, Cal., then one at Grand Island, Neb., and another one at Norfolk, Neb. Previous to the advent of the Oxnards and their taking a prominent part in the early struggle to establish the beet sugar industry on the Pacific Coast, a factory had been built at Watsonville by Claus Spreckles. The movement then extended to Utah and New Mexico, resulting in the establishment of factories at Lehi, Utah and Pecos, N. M.

The success of these seven factories 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.

THE INDUSTRY AWAKENING TO REAL LIFE.

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

With the year 1897 a new era was ushered in for the industry. It was not until then that it awoke to real life, and its vast importance was recognized in general business circles. In 1899 the number of factories had increased to 18. During the campaign of 1899-1900, thirty factories were in operation, and there were six added to this number for the past campaign 1900-1901.

The following table gives name, location and capacity of these factories:

BEET SUGAR FACTORIES IN THE UNITED STATES.

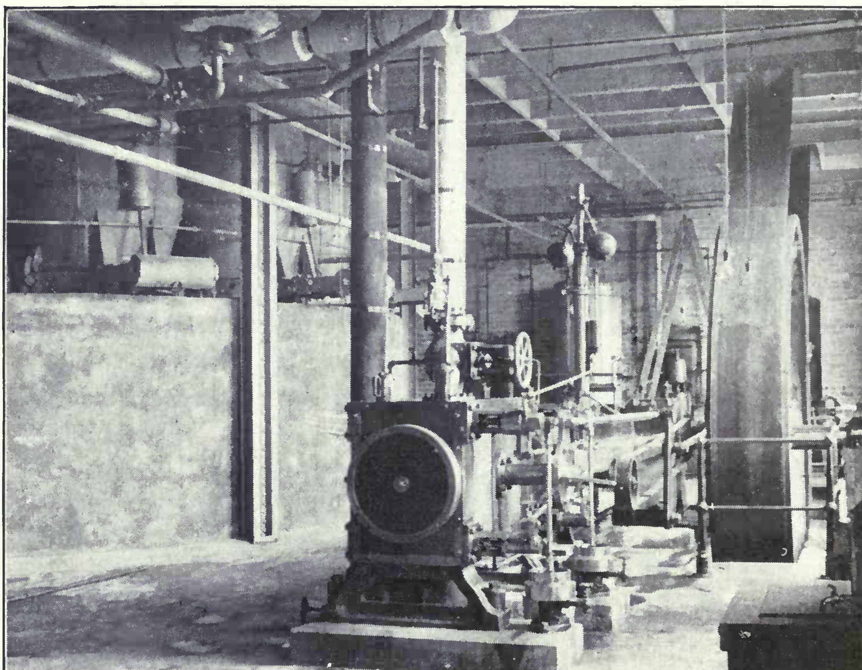
NAME.	LOCATION.	DAILY CAPACITY.
Alameda Sugar Co.	Alvarado, Cal.	800 Tons
Western Beet Sugar Co.	Watsonville, Cal.	1,000 "
Chino Valley Beet Sugar Co.	Chino, Cal.	1,000 "
Los Alamitos Sugar Co.	Los Alamitos, Cal	700 "
California Beet Sugar and Refining Co	Crockett, Cal.	1,200 "
Oregon Sugar Co	La Grande, Ore.	350 "
Utah Sugar Co.	Lehi, Utah	350 "
Ogden Sugar Co.	Ogden, Utah	350 "
Pecos Valley Beet Sugar Co.	Carlsbad, New Mex.	200 "
American Beet Sugar Co.	Grand Island, Neb.	350 "
" " "	Norfolk, Neb.	350 "
" " "	Oxnard, Cal.	2,000 "
Minnesota Sugar Co.	St. Louis Park, Minn	350 "
Michigan Sugar Co	Bay City, Mich.	350 "
First New York Beet Sugar Co.	Rome, N. Y.	200 "
Binghampton Beet Sugar Co.	Binghampton, N. Y.	350 "
Spreckles Sugar Co.	Salinas, Cal.	3,000 "
Union Sugar Co.	Santa Maria, Cal.	500 "
BUILT 1899-1900		
Illinois Sugar Refining Co.	Pekin, Ill.	700 "
Alma Sugar Co.	Alma, Mich.	600 "
Bay City Sugar Co.	Bay City, Mich.	600 "
Colorado Sugar Mfg. Co.	Grand Junction, Col.	350 "
Detroit Sugar Co.	Rochester, Mich.	500 "
Kalamazoo Beet Sugar Co.	Kalamazoo, Mich.	500 "
Holland Sugar Co.	Holland, Mich.	350 "
Penninsular Sugar Refining Co.	Caro, Mich.	600 "
Standard Beet Sugar Co.	Ames, Neb.	500 "
Washington State Beet Sugar Co	Waverly, Wash	350 "
West Bay City Sugar Co.	West Bay City, Mich.	500 "
Wolverine Sugar Co.	Benton Harbor, Mich.	350 "
BUILT 1900-1901.		
American Beet Sugar Co.	Rocky Ford, Col.	1,000 "
Continental Sugar Co.	Fremont, Ohio.	350 "
National Beet Sugar Co.	Sugar City, Col.	500 "
Empire State Sugar Co.	Lyons, N. Y.	600 "
Marine Sugar Co.	Marine City, Mich.	350 "
Utah Sugar Co.	Springville, Utah	350 "

From the foregoing table it will be noticed that at the present time the larger number of factories, with by far the largest capacity are located in the Pacific Coast States, that as far as single states are concerned, the State of Michigan stands at the head of the list with nine factories, whose combined capacity however is only about one-half of the rated capacity of the 8 California factories. California undoubtedly however may claim the honor of being the pioneer state of the industry. The progress of the industry in California and the practical demonstration furnished thereby as to the value of the industry in advancing farming, commercial and transportation interest, in making productive and enhancing the value of thousands of acres of idle and non-productive land, which had been either unprofitable or valueless, in making an oasis out of a desert, in working transformation scenes, which were nothing short of miraculous, certainly presented a strong object lesson to other states. But these changes were not accomplished without a struggle. There were strong influences to counteract and the champions of the industry in its early stages of development in California, met with many disappointments. Prof. E. W. HILGARD of the University of California who has done so much to advance the beet sugar industry in this country, in the "*Pacific Rural Press*" of December 1897 aptly described the contest in California as follows:

> "It is interesting at this time to recall these early experiences and note the recent repetition of similar ones, when beet sugar threatened to compete with the "colonial" product almost on its own ground; for in Southern California at least, a patch of cana dulce formed, and to some extent still forms a part of the home comforts of most of the native California cultivators; and the expansion of its culture there appears to be purely a commercial question. It was here, in the fields of Los Angeles that the sugar beet and the sugar cane—the two competitors for the championship of the world in sugar production—met face to face perhaps for the first time in the history of the industry; one of the many examples afforded by the Californian climate of the bringing-together of cultures elsewhere separated by wide climatic and geographical intervals. But the real conflict was not in the cane patches and beet fields of Los Angeles. The great Hawaiian cane plantations were on one side; on the other the struggling beet-sugar factories of the central part of the state, against which were then wielded the same weapons that were employed at the beginning of the century in the same fight by the English colonial interest, and to which all but one —the Alvarado "Standard Sugar Refinery"—succumbed."

Whether California will retain its rank as the largest beet sugar producer remains to be seen. It is unquestionable that thus far California has produced the richest sugar beets. Its soil seems particularly adapted for the industry and likewise the climate. There is one serious drawback connected with the latter, namely, the frequent droughts, causing sometimes total failures of the crop season after season. There are several of the states of the Middle West, which I think will forge ahead after a while and which, though they may not produce a beet as high in sugar content than California, but will give a sure crop year after year, not having to content with droughts, hot winds and other climatic drawbacks.

The wonderful and rapid growth of the industry in the State of Michigan, to a considerable extent is due to the enactment of a bounty bill passed in 1897, but just declared void by the Supreme Court of the State. There is, however, no doubt that even without the bounty law the State of Michigan by reason of the natural advantages, which its soil and climate offer, was bound to get in the front rank of the industry. Last year when the largest number of factories was built in the State of Michigan, the litigation between the factory owners and the state auditor had already commenced, and the verdict now given, declaring the law unconstitutional, was anticipated by most of those who invested in the industry. They knew at any rate that at best the bounty would only



A GLIMPSE INTO THE ENGINE ROOM OF THE MICHIGAN SUGAR CO.'S FACTORY AT BAY CITY, MICH.

be given for a year or two and certainly would not have invested so largely, unless they had felt sure that the industry would pay without subsidy.

The establishment of the industry in Michigan almost forced itself on the land owners as a consequence of the decline of the lumber industry of the state. The question had been often asked—what would be the fate of Northern Michigan when its fast disappearing pine timber was entirely gone; what would become of the busy towns and cities whose principal, if not sole industry was the lumber trade, and whose prosperity and existence was dependent upon the men employed in the woods and lumber mills?

It was taken for granted that the sandy soil of Michigan would produce little or nothing. In the pursuit of solving the question of the utility of the sandy soil of Michigan and to replace a waning industry by a new one, the land owners had their attention directed to the culture and production of sugar beets. It is perhaps not saying too much that the introduction of the sugar beet industry in the State of Michigan was the only solution of the problem. I do not wish to be understood as denying the incentive that was given by the bounty law to the growth of the industry, but the conclusion seems warranted that even without it, it would have gained a firm footing in that state. In this connection a few remarks on the bounty question would seem pertinent.

SUGAR BOUNTY SYSTEM AND ITS INFLUENCE ON THE INDUSTRY.

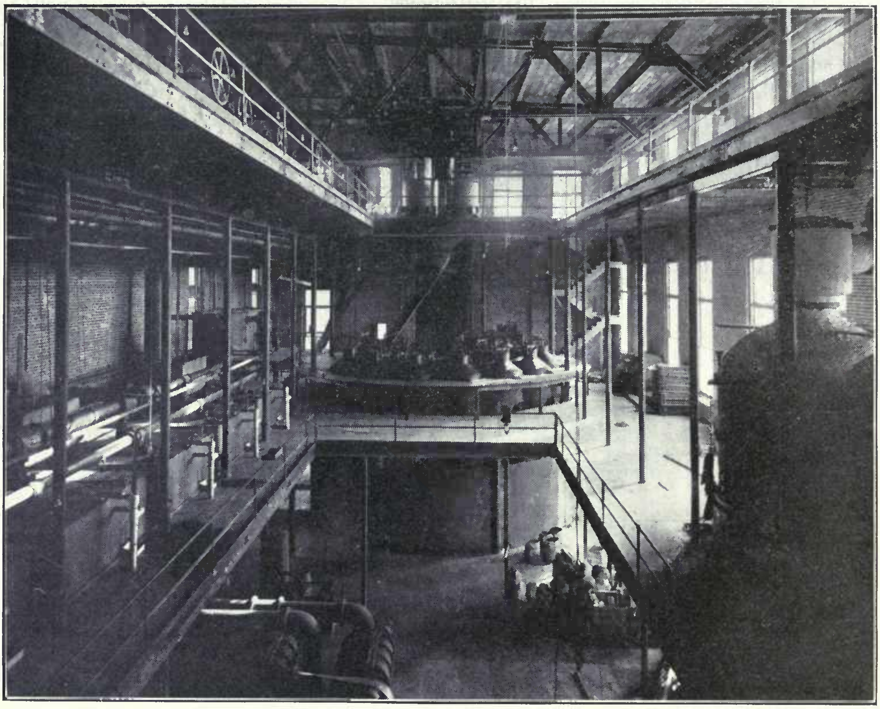
This question has been agitated more or less in most every state in which beets may be raised, but with the exception of Minnesota, New York, Pennsylvania and Washington, no other state has a bounty law on its statute books. So far as the foregoing four states are concerned, both amount of bounty and time during which it is to be paid, are limited. The fact that Minnesota has but one factory, New York only two, and Pennsylvania not even one, would seem proof in itself that our people fully comprehend that a bounty law is after all not such a big factor. And it is not also a fact that those states of the Union, producing the larger quantity of our sugar, are states which have no bounty law.

While in general it is pretty well understood that there is no need of artificially fostering the industry, the agitation in favor of bounty-laws is still going on in many states. It is probably owing as much to the mistake of laying altogether too much stress on this bounty feature and its indiscriminate agitation, as to other mistakes that the starting of the industry in a number of states has been delayed.

There can hardly be any question that the bounty principle *per se* is wrong, especially under the high protective tariff on imported sugar.

In the European Export Bounty System, which as a notorious fact has become a source of trouble, both for its intended beneficiaries and its dispensors we can readily perceive the dangers which lurk in such a system. The strenous efforts made for several years now in Europe to abolish the system, presents conclusive proof that it has not stood the test. Upon the instigation of some of the governments and societies representing producers in the principal sugar beet raising countries of Europe, conference upon conference has been held, but without result. It has been plainly shown that most of the producers would gladly dispense with bounties, in order to escape discriminating duties, at the same time the tremendous difficulties standing in the way of the movement for the abolition of bounties have been clearly demonstrated. The society of German sugar producers, representing the country producing the largest beet sugar crop, has repeatedly adopted resolutions, declaring that the abolition of bounties would be acceptable to them, provided all countries abolished both direct and indirect bounties. But so far all efforts to get the various beet sugar producing countries to act in concert, have utterly failed.

Here we see then the evil consequences of this policy of artificially fostering an industry: The governments have assumed a sort of obliga-



A GLIMPSE INTO THE INTERIOR OF THE DETROIT SUGAR CO.'S FACTORY, ROCHESTER, MICH.—South End.

tion towards their beneficiaries, who have invested large amounts of money in the industry on the strength of promises, which the governments are in honor bound to redeem. They stand in the same relation toward their beneficiaries as one business individual to another. A man cannot go back on his contract without forfeiting his reputation for honesty and fair dealing, and so it is with governments. A wrong course once taken is hard to abandon or correct. This is the experience of the European Governments relative to abolishment of sugar export bounties. Of course there is no intention on the part of our

Government to offer a sugar export bounty. The drawback in former years rebated to the sugar manufacturer was simply a refund of import duties on raw sugar, re-exported in the form of refined sugar. But, leaving aside ancient history and the part the Sugar Trust played in the time when the memorable changes in the sugar tariff legislation took place, the point I wish to make is that we can learn a profitable lesson from the experience of the European sugar industry with export bounties. As long as a bounty law which gives so much a pound to the beet grower and the sugar manufacturer is meant as an inducement to encourage home production and to give the industry a fair start, and, furthermore, as long as it is safeguarded by its provisions to attain only this end, the dangers which might otherwise lurk in it may be obviated. The permanent establishment of the industry, however, must depend not on national legislation nor State aid, either of which can only be temporary at best. Moreover, the beet sugar industry in this country is so firmly established that it is able to get along without the questionable help represented by the bounty system, and there is no need of artificially fostering the industry and inviting such evil results as over-production, unfair taxation, higher cost of the sugar to the home consumer, etc., as the bounty system has usually carried in its wake.

It is safe to assume that sooner or later the European Governments will have to come to an understanding on this question. They are beginning to acknowledge the error of their policies of forcing the industry by means of bounties. The cry of the West Indian sugar planter, whose industry was ruthlessly destroyed by the sugar beet farmer of Continental Europe, is now uttered by the latter himself. This certainly is a strong object lesson for our people interested in the industry to take to heart.

In concluding the historical review of the beet sugar industry in the United States I append a table showing the increase in production year by year, from 1830 to 1899;

PRODUCTION OF BEET SUGAR IN THE UNITED STATES FROM 1830 TO 1899.

(From the Weekly Statistical Sugar Trade Journal.)

1830	A few hundred pounds	1886	800 tons
1831–1837	None	1887	255 "
1838–1839	1,300 pounds	1888	1,010 "
1839–1862	None	1889	2,600 "
1863–1871	300 to 500 tons per annum	1890	2,800 "
1872	500 tons	1891	6,359 "
1873	700 tons	1892	12,091 "
1874–1877	Under 100 tons per annum	1893	20,453 "
1878	200 tons	1894	20,443 "
1879	1,200 "	1895	30,000 "
1880	500 "	1896	37,536 "
1881–1882	Less than 500 tons	1897	40,399 "
1883	535 tons	1898	32,471 "
1884	953 "	1899	72,944 "
1885	600 "		

PRESENT STATUS OF THE INDUSTRY IN THE UNITED STATES.

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 most 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 raised in any part of the old world.

(In a late report by United States Consul Brittain, at Nantes, made to the department, 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 fully 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 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 larger 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 rapid development of the sugar beet raising and beet sugar manufacture was the fact that capital has not become sufficiently interested in it. The farmer is simply waiting for the capitalist 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 fifty to seventy bushels to the acre. The farmer received therefor, on an average of sixty bushels to the acre at 10 cents, say $6.00 per acre all told, and from this amount 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 $40.00 to $50,00 per acre, and in California $60.00 to $70.00 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 $25.00 to $30.00, 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 them 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 1750 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 annually to foreign countries, while we could and should produce all the sugar we consume in our country. While four European countries, Germany, Austria, France and Russia, boast of over 1,400 beet sugar factories, up to last season we had only thirty. We produced during the season 1899–1900 205,000 tons. (Beets, 73,000.) 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 $100,000,000, 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?

FUTURE OF THE INDUSTRY.

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 pounds per capita; in 1840, 25 pounds; in 1850, 30 pounds; in 1860, 35 pounds; in 1870, 40 pounds; in 1880, 45 pounds; in 1890, 53 pounds, and in 1895, 63 pounds.

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 EURORE.

(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	4,739,000	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

Annual increase in consumption in the United States for the last twenty-three years gives an average of 12 per cent. per annum, 240,000 tons, meaning about

70 factories of 350 tons daily capacity, or
50 " 500 " " "

or in other words, that for an *increase in consumption alone* in ten years

700 factories of 350 tons capacity, or
500 " 500 " "

would be required.

Supposing for the next ten years the average increase in consumption should not exceed 150,000 tons per annum, such increase alone would require each year at least forty additional average sized factories of 350 tons capacity, representing an investment of at least $14,000,000, or within ten years from now at least 400 such factories, costing about $140,000,000, would be required to supply the increase in consumption alone. The probability, however, is all in favor of a much heavier increase, as, owing to the low price of sugar of late years, the consumption in certain trade fields has been vastly stimulated, while new consumptive channels have been opened. The increase of sugar consumption in the confectionery trade may be cited in support of my contention.

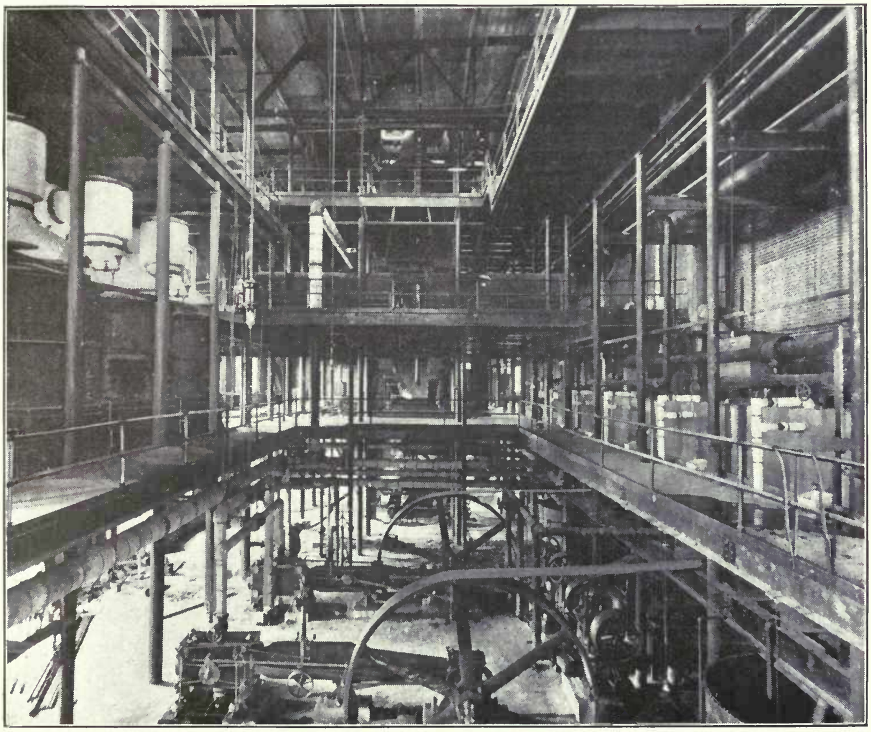
The value of confectionery products in this country was:

In 1850	$ 3,000,000
In 1860	5,000,000
In 1870	15,000,000
In 1880	25,000,000
In 1890	55,000,000

and leading manufacturers in this line estimate the value of this year's product at $75,000,000.

The time was when candy was imported to a considerable amount into this country, but nowadays very little is brought into the United States, as better goods are made here and at less money than the foreign candy costs.

The total output of the thirty factories which were in operation in the campaign of 1899–1900 amounted to 73,000 tons, or, in other words, about 50 per cent. of the annual increase in consumption.



A GLIMPSE INTO THE INTERIOR OF THE DETROIT SUGAR CO.'S FACTORY, ROCHESTER, MICH.—North End.

From the tabular statement it will be seen that England is still at the head as sugar consumer, consuming the largest amount of sugar per capita of any nation. Of course the per capita figures include sugar used in various manufactured articles, a portion of which is shipped for consumption to other countries. The United States come next to England, with a present per capita consumption of about 65 pounds, but 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 five years from 1890–95 the population of England has increased less than one million, while our population has increased nearly eight millions. 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.

WHAT THE INDUSTRY MEANS TO OUR PEOPLE.

It means that if we were to manufacture all the sugar consumed in the country our farmers would have to produce annually at least 55,000,000 tons of sugar beets, giving them, at a low calculation $222,-000,000. 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 bell-hanger 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 the factories, and another army of men would be employed in coal mines, limestone quarries, chemical and other factories. In fact there is hardly a branch of trade that would not be benefited 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 6,500,000 tons of coal, 4,400,000 tons of limestone, 500,000 tons of coke, besides a vast quantity of chemicals and other material.

Is there any good reason why we should not do all this ourselves, instead of allowing it to be done in foreign countries, which buy comparatively little from us, or which discriminate against our products? And can there be any question whether the sugar beet industry will thrive in the United States, and whether it will offer a safe and profitable investment for capital? Certainly not.

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. I 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 country, and, when instead of being the largest importers of sugar, we shall become an exporter of this paying staple. And why not? There is absolutely no reason why, after supplying our own people, we should not enter the sugar markets of the world as a competitor.

We have accomplished such seeming impossibilities before. For instance, it is not so long ago that we used to import largely raw materials and manufactured goods in the iron and steel line. To-day our iron and steel products successfully compete with the products of the older industries of Europe in every known market of the world. Everything made in this line, from a two-penny nail to a complete railroad engine, are shipped by us to every nook and corner of the world. If the assertion had been made fifteen years ago that we would furnish Great Britain with railroad locomotives it simply would have been ridiculed, and yet this is a fact to-day. What we accomplished in this line we can accomplish in others, and it is my strong belief that the day is not so far distant when, instead of receiving sugar from foreign countries through a few seaports, sugar will be shipped out from a large number of points all over the United States as one of our staple export articles.

It is but natural that the importing industries and those who have made it a business to refine sugar from imported raw material should look with disfavor upon this new industry and try to arrest its progress. In any new process of commercial and industrial evolution, such as the growth and development of the beet sugar industry involves, some interests are bound to suffer, but the question simply is, will the greater mass of our people benefit by such changes? In the present instance this question can be answered most emphatically in the affirmative.

THE ECONOMIC SIDE.

Why We Should Raise Sugar Beets and Produce Our Own Sugar.

First—Because if any country in the world has the predestination to become the center of sugar production it is the United States, no country being more favored by its natural resources to produce sugar, one of the most important articles of daily consumption.

Second—Because there is enough beet land in the United States, nay, even in single States to enable us to raise enough beets and to make sugar enough to supply our home needs and a surplus which could be profitably exported.

Third—Because it will tend to renovate and make productive many of our farm lands that are now unprofitable and valueless, furnishing remunerative work to a large number of people, restoring hope and bringing prosperity to many neighborhoods where despondency and poverty now prevail.

Fourth—Because with present low prices for grain, cotton and other agricultural products the farmer should grow such crops as give the best returns for the expenditure of his capital and labor.

Fifth—Because sugar beet raising gives the farmer many times the profit that could be derived from any other crop, while it does not interfere with any other agricultural product, but, on the contrary, by improving the condition and capacity of the soil, produces better grain crops, besides permitting the growth of such profitable crops as barley and other high culture vegetables, which could not be raised profitably before.

Sixth—Because with the introduction of sugar beet culture in our farming system, rotation of crops and economical and extensive cultivation become possible, increasing the productivity of the land and likewise increasing its returns.

Seventh—Because anything that promotes the good and welfare of our agriculturists is good for the nation at large. The wealth of a nation largely depends upon its agriculture. Wherever this is neglected decadence is sure to follow, where it is fostered, prosperity will increase.

Eighth—Because beet raising and sugar making means supplying a large quantity of fodder and cheaper dairy and meat products. Beet raising and stock raising go hand in hand. The beet pulp from the factory feeds the stock and the manure from the stable gives back to field what the beet took from it.

Ninth—Because sugar beet culture and beet sugar manufacture will give employment to additional labor and capital. It will require a great army of industrial laborers in the fields, in workshops, in mines and in factories, in railroad and other transportation circles, and many other business enterprises, besides offering an opportunity for profitable investment for hundreds of millions of dollars of capital.

Tenth—Because it would keep in the country the vast sum of over $100,000,000 in gold to be divided under our people, and principally our farmers, which sum is now sent abroad annually to pay for our sugar bill, and because it is against all common sense that we should buy that which we can profitably raise and manufacture in our own country.

Eleventh—Because as long as the words "sugar deficit" appear in our statistics it is obviously of the greatest importance for our country to increase the domestic sugar production.

Twelfth—Because the development of this industry will cheapen the cost of sugar to the consumer, and because no other kind of business is such a wealth producer, nor put so much money in general circulation. The following figures, showing the average disbursements of a 500-ton capacity beet sugar factory during one season, may show the importance of this industry.

Amount paid to farmers for beets	$225,000
Freight paid by farmers to railroad companies	15,000
Freight paid by factories to railroad companies	30,000
Coal	18,000
Limestone	8,000
Coke and other material	37,500
Wages	40,000
Salaries, selling commission, etc	50,000

The aforestated reasons, important as they are, numerically include only a small fraction of those that might be cited. It is one of the subjects which grows in importance with closer study. When we consider how many industries are touched and enlivened through beet culture and beet sugar making, the question, should we produce all the sugar we consume, hardly requires further argument.

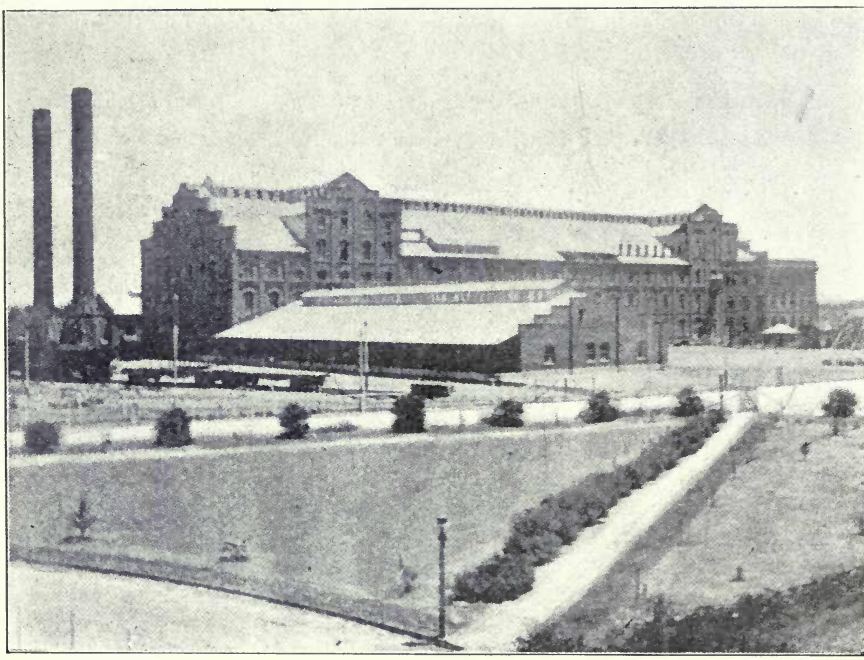
From the foregoing also the question:

"IS THERE MONEY IN BEET RAISING AND SUGAR MAKING?"

answers itself in a satisfactory manner. Wherever our farmers have started to raise sugar beets for the factories the value of lands has trebled, quadrupled and even quintupled, which means that the price of lands near the now existing and operated beet sugar factories has risen from $50.00 to $100.00, to $200.00 and $350.00 per acre within two years after the factories were started. Apparently sterile plains have been turned into farms of unparalleled productivity.

It is but a short decade ago that the traveler through certain parts of California, Nebraska, Michigan and other Western States where factories are now established would pass through vast regions of land covered by thousands of acres of giant trees, or unsightly stumps, or endless prairies of wild grass or sage brush, dreary wilderness, as laying in deep silence, only interrupted at long intervals by the ring of the woodman's axe. And to-day the transformation scene is almost miraculous. The same traveler would find well kept farms, substantial houses, the homes of happy and contented farmers, whose well-filled granaries and barns are silent witnesses of their prosperity, and all this wonderful change has been brought about by the sugar beet. One might have guessed that these lands might some day become a source of wealth, but it required a more than vivid imagination to see in the mind's eye the thousands of acres of varied crops, green fields dotted with cows, sheep or cattle, snug farm houses and barns and the tall chimneys of sugar houses, whose products run up into the millions.

Here are a few instances: Take the country around the Chino factory, in the Pomona Valley, California. Nine years ago it was part of a big ranch, nothing growing there but sage brush and wild grass. It was a dreary and desolate spot. Now, as far as the eye can see from the factory the land is laid out in fine looking farms, and during the beet season it is gleaming with thousands of beet tops. A busy town has grown up near the factory, and the land which nine years ago was only worth $15.00 per acre as grazing land, is worth now from $250.00 to $350.00 per acre. More wonderful still, at Watsonville, California, a tract of land of 12,000 acres, practically unused previous to 1891, has since grown beets worth one-half million dollars in one season. A town of some 4,000 inhabitants has grown up around the factory, and from $241,000 in 1890 the assessed valuation has risen to over $4,000,000. The country in the middle of which now stands the Alamitos sugar factory was transformed inside of two years from a wilderness into vast beet fields.



AMERICAN BEET SUGAR COMPANY'S FACTORY, OXNARD, CAL.
(Front View.)

Around Eddy, New Mexico, through the advent of a sugar factory, some 6,000 acres of wild cattle ranch land was changed into beet fields, the value of the land enhancing from $5.00 to $150.00 per acre and more inside of three years. This is the experience which we find repeated in every location where a beet sugar factory has been started.

As far as the capitalist is concerned, he need only inquire of those who had the courage to start the new industry in this country as to what their experience has been, and he will be astonished at the tremendous success and the profits made by the pioneers of the beet sugar industry under less favorable conditions than existing now.

It is a matter of record that the Spreckles factory, at Watsonville, California, paid in four years 117 per cent. dividends. The outside stock of this factory was sold in 1897 at $300.00. This stock cost the original owners $100.00, thus giving the stockholders a total return of $417.00 for their $100.00 investment in four years. The first dividend after the purchase of the stock was then 80 per cent. The Lehigh, Utah, factory is said to have paid for several seasons a dividend of 37⅓ per cent. after putting a large percentage of its early profits into improvements. A short time ago it was stated in public prints that the earnings of the Michigan Sugar Company's factory at Bay City amounted in two seasons to 105 per cent. on its capital stock. The American Sugar Refining Company has paid on over $36,000,000 preferred stock outstanding, 7 per cent. on over $100,000,000 common stock (mostly water when compared with actual cost of its refineries), 12 per cent. yearly dividends. In many factories the stockholders were returned in one season about one-half of their investment, and I venture to say that a well managed factory will pay for itself under half-ways favorable circumstances in not more than three years.

THE SUGAR TRUST—WHAT ABOUT IT?

The Sugar trust makes its money by refining sugar imported raw into the United States, principally cane sugars, as will be seen from the following statistics showing imports into the United States of cane and beet sugar from 1890 to 1899.

CANE SUGAR.	1899.	1898.	1897.	1896.	1895.
Cuba	246,106	257,228	209,453	251,522	816,687
Porto Rico	48,376	42,400	32,212	29,841	28,276
Philippines	22,067	26,440	11,657	61,382	31,545
Hawaii	130,841	91,009	89,890	46,183	20,490
Sundry foreign countries	1,059,256	747,035	604,742	687,286	412,791
Beet sugar—Europe.	258,705	206,087	637,246	523,232	115,049
Total	1,755,351	1,370,199	1,585,200	1,599,448	1,424,638

CANE SUGAR.	1894.	1893.	1892.	1891.	1890.
Cuba	951,439	623,080	779,546	651,209	479,589
Porto Rico	31,402	35,453	50,977	34,249	29,317
Philippines	29,235	63,989	66,604	34,915	39,048
Hawaii	....	....	....	....	....
Sundry foreign countries	423,283	447,159	334,069	383,266	346,148
Beet sugar—Europe.	164,320	248,440	149,482	331,128	289,214
Total	1,599,699	1,415,121	1,380,678	1,435,767	1,183,316

The following are the average prices for raw sugars, duty paid at port of entry, for the last seven years:

	96° CENTRIFUGAL.	FAIR REFINING.
1899	4.419	3.92
1898	4.325	3.743
1897	3.557	3.071
1896	3.624	3.157
1895	3.27	2.925
1894	3.24	2 60
1893	3.689	3.20
1892	3.311	2.81
1891	3.863	3.37
1890	5.445	5.01

It takes 107 pounds of raw sugar to make 100 pounds of granulated. The cost to the trust, based on 1899 average prices, calculate about as follows:

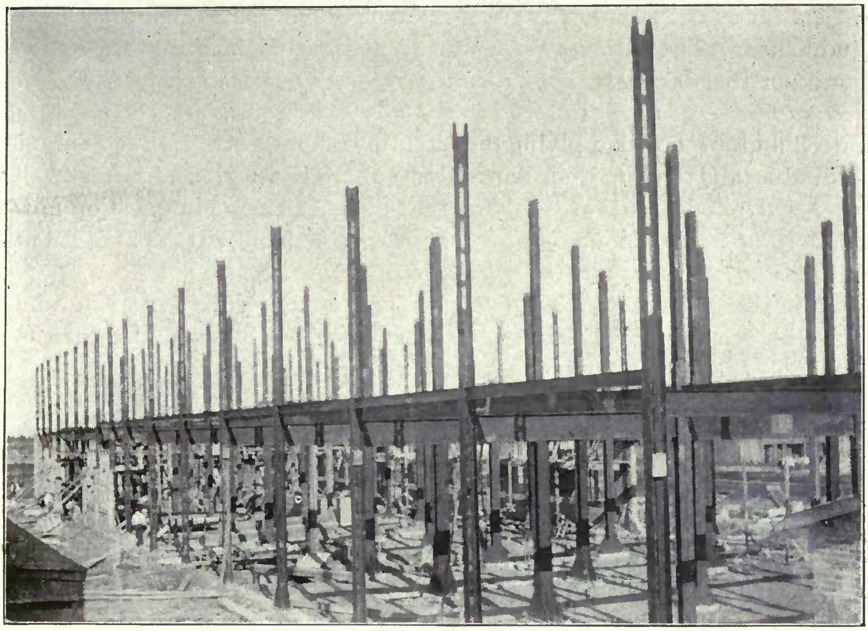
107 pounds at 4.119	$4.407	107 pounds at 3.92	$4.194
Cost of refining	.35	Cost of refining	.35
Freight	.35	Freight	.35
	$5.107		$4.894

The trust must clear about twelve million dollars per year to pay interest on stock and water. Of the 2,000,000 tons of refined sugar which went into consumption in 1899, the trust is credited with having manufactured about 68 per cent., or, say, 1,360,000 tons. The trust, therefore, had to add about forty cents per hundred pounds to the above cost figures. According to Willet & Gray, the difference between raw and refined sugar per pound averaged 50 cents during 1899, as against 73 cents per pound in 1898. A short time ago 96° centrifugal raw sugar was selling in the open market at 4.625 cents per pound, while standard granulated was then quoted at 5.60 cents (less gratuity of 0.15 cents per pound, and 1 per cent. for cash), hence if the refiner obtained the full net price, and the difference in his favor was 77 cents per 100 pounds, out of which he had to defray all expenses of refining, but in all probability they were not receiving the full net prices, and the difference was most likely nearer to 50 cents or 60 cents, and even at this lower figure the refiners were not selling at a loss, according to the testimony of Mr. Havemeyer and other Sugar Trust magnates, as lately given before the Industrial Commission. According to James H. Post, of B. H. Howell, Son & Co., the cost of refining for 100 pounds amounts to about 35 cents, and the loss of weight in refining to about 28 cents, hence it would seem that a margin of at least 63 cents for 100 pounds between the two products would be necessary. A well managed average sized beet sugar factory ought to be able to produce standard granulated sugar at 3 cents per pound and less. The beet sugar manufacturer, therefore, has an advantage which would more than outweigh the present sugar duty if it were taken off. Of this latter eventually, however, there is not the remotest chance. In this connection the following distribution figures, as given by Willett & Gray, may be of interest.

United States total consumption, 1899, 2,040,676 tons (of 2,240 pounds).

American Sugar Refining Co.	1,384,608 tons	67.9 per cent	67.2 per cent.
Independent Refiners	585,767 "	28.7 "	28.2 "
Beet sugar refiners	63,368 "	3.1 "	1.8 "
Foreign imported	5,935 "	0.3 "	11.8 "
	2,039,678	100 "	100 "

Consigned in raw or plantation condition, 1899..53,934 tons......1898....141,811 tons
Stock of undistributed refined sugar, 1899.......20,000 " ......1898... 25,000 "



MODERN FIRE-PROOF SUGAR PLANT CONSTRUCTION, SHOWING CONCRETE FOUNDATIONS AND STEEL COLUMNS.

CONCLUSION.

Beet culture and the manufacture of sugar from beets is one of the great economic questions of the day. It is of equal importance to the farmer, manufacturer, capitalist and statesman, and hence we find it agitated and discussed by our agricultural and trade journals, the daily press, State boards of trade, farmers' and manufacturers' associations, Government and railroad officials, capitalists, economists, in fact every thinking man. 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, directly and through its stations 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 domain—(it is probably the only industry at present in the United States *paying in a bona-fide way 25 per cent. and more* net profit on capital invested)—seems gradually to be 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 of our States.

As far as the supply of acreage is concerned the industry is firmly established. The farmers were slow to get started in it, but they soon found out that *the profits from raising beets were so much greater than those received from growing grain or other produce.* Those farmers who once got started and are now supplying the factories in existence, all are anxious to double and treble their acreage and there is a legion of farmers all over the United States anxious to plant beets. The main question now seems to be how can such a prospective crop be handled? There is but one answer, and that is: *More factories.*

The capitalists 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.*

The development of the industry during the past few years has been nothing short of phenomenal, but there is a still brighter outlook for it.

Predicating the opinion upon some of the facts set forth in the preceding pages, I feel confident that in not too far a time we shall be able to raise all the sugar we consume.

PART II.

THE CULTURE OF THE SUGAR BEET.

INTRODUCTORY.

There is no agricultural product from which the industrious farmer may derive so many advantages as from the sugar beet. Sugar beet raising gives the farmer many times the profit that could be derived from any other crop, while it does not interfere with other crops, but on the contrary by improving the condition and capacity of the soil, owing to continuous and superior cultivation, produces better grain crops, besides permitting the growing of other high-culture plants and vegetables which could not be grown profitably heretofore.

With the raising of larger and more valuable crops naturally the value of the land increases. The beet, furthermore, produces fodder, and hence more manure. Through it the farmer is enabled to increase his live stock without hardly any increase in expense. The final result of all this is prosperity written in capital letters.

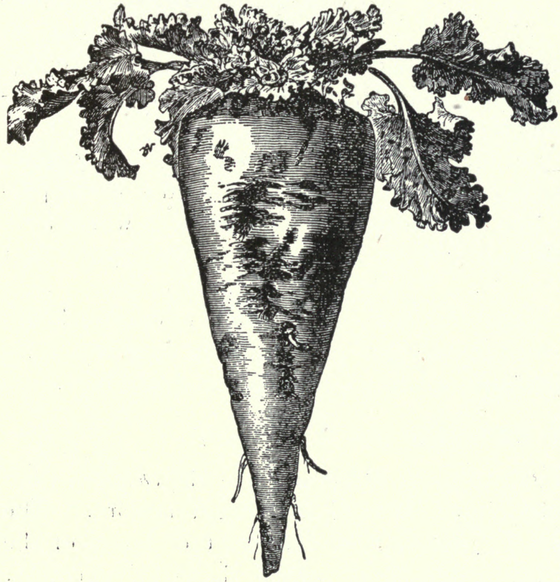


Fig. 1.
KLEINWANZLEBENER.

Many of our States, as shown by extensive experiments, are well adapted for the raising of sugar beets, and contain in the largest measure every condition necessary for the successful and fruitful development of the beet sugar industry, but, as has been the case in Europe, the successful and permanent establishment of the industry will depend on the interest which intelligent farmers will take in raising a sugar beet which will fill all the requirements of the factory. On the quality of the beet depends to a large extent the success of the factory. A mere high percentage of sugar in the beet, however, is not the sole requirement, although a most important one. Besides the largest possible amount of sugar, a good beet should contain the smallest percentage of foreign substances, whether saline, nitrogenous or indifferent non-nitrogenous organic compounds. Purity in the beet is of as much importance as sugar content, for factory experience has established the fact that every one per cent. of foreign admixture will render about 1½ per cent. of sugar in the juice uncrystallizable, converting it into less valuable molasses.

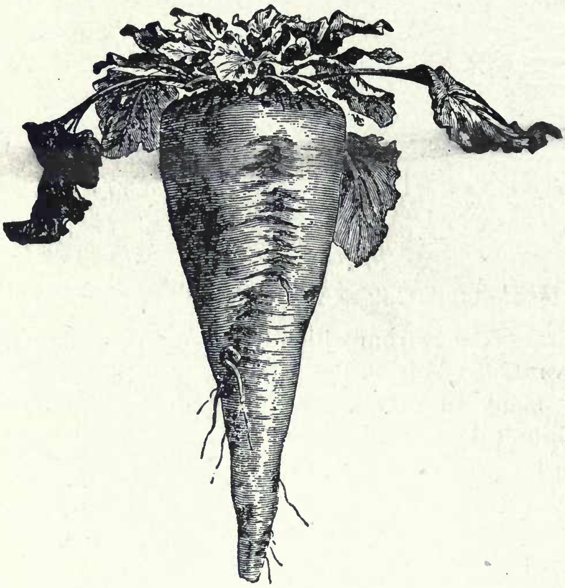


Fig. 2.
VILMORIN.

It is of the utmost importance that the farmer wishing to engage in beet culture should fully understand the niceties of it, and it is the purpose of these pages to aid him in the dissemination of facts which have been instrumental in the development of the culture in European beet growing countries.

Before entering into detail on the subject of beet culture I will explain which constitutes a good beet for sugar making purposes. To do this it is necessary to first give a short history of the sugar beet.

HISTORY OF THE SUGAR BEET.

The beet (*Beta vulgaris*) is a plant of the order of the *chinspodiaceae* (goosefoot family), and was known far back in ancient history. 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, vastly differing in color and quality. In the works of Pliny, the younger, it is described as a sugary vegetable plant, and it would, therefore, appear that already at his time (61–113 A. D.) the beet was utilized as an article of food. However, it seems to have been the dark red beet, which to-day is still used upon our tables as salad or pickled, which were preferred to the varieties of a paler color for eating purposes. The supposition is that this red beet, respectively the sugar beet, was introduced into Germany, as most of the cultivated plants, by the Romans, during the time of their invasions into Germany.

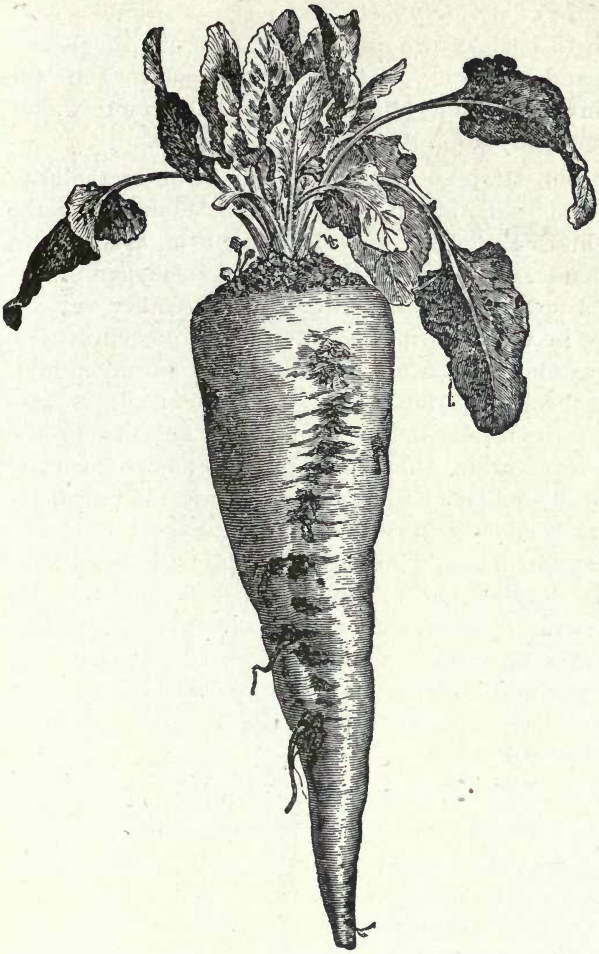


Fig. 3.
VILMORIN. (LE PLUS RICHE.)

There are some forty varieties of beets in the United States, which may be divided into three succinct classes, viz.: those used for human food; second, those used for stock feeding, and third, 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, Vilmorin and the Mangold are representatives of the third class.

VARIETIES OF SUGAR BEETS.

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, and even higher. 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 shape and size of the beet, its color, the color and character of the foliage, are their distinguishing marks.

The varieties of beets best known in this country are the Kleinwanzlebener, Vilmorin and Mangold. The first two mentioned are the best known. The Kleinwanzlebener (Fig. 1) is probably more widely grown in this country than any other variety.

It has a conical root, straight and even, quite large at the head and rapidly tapering, and is distinguished from the Vilmorin by the brighter color and brighter colored leaves. The Vilmorin, as shown in Fig. 2, is of a more slender shape than the Kleinwanzlebener. It is claimed that it holds its sugar contents better than any other variety, and in those factories in which it is worked up in connection with other varieties it is customary to work up all other varieties first, reserving the Vilmorin beets for the end of the season. It is also claimed that the Vilmorin resists better than any other variety the unfavorable influences of certain characters of soil and of certain manures. It thrives well in black soils rich in organic matter where other varieties of beets become watery or saline in excess. Heavy quantities of nitrogenous fertilizers, which are carefully excluded from other varieties, can be applied with safety to the Vilmorin. Its average percentage of sugar is about 16 to 18 per cent., and its average yield per acre under favorable conditions fourteen tons. The average yield per acre of the Kleinwanzlebener is given as fifteen tons, but it is generally not as rich in saccharine as the Vilmorin, running about 14 to 15 per cent. of sugar.

The Vilmorin (*Le Plus Riche*), the general character of which is shown by Fig. 3, is superior in its yield to the Vilmorin and Kleinwanzlebener, running 14 to 16 per cent. sugar in the beet and yielding from eighteen to twenty tons per acre. It grows entirely under the soil, is more slender than either the Vilmorin or Kleinwanzlebener, has a ruddier skin and more compact flesh. It carries a foliage vigorous in growth and upright in position.

The Mangold shown in Fig. 4 is the outcome of a careful crossing of the Vilmorin with one of the former Knauer specialties and somewhat similar in shape to the Vilmorin. Its sugar percentage ranges from 16 to 18 %, and the yield in tons per acre is fully up to other standard varieties. It has but little subsidiary root, but a strong compact form of tuber, which may be considered a special advantage from the sugar manufacturer's standpoint. The flat disc shaped arrangement of the finely curled leaves cause this variety to mature early, provided, of course there is propitious weather in the months of August and September. Besides early maturity, a high quotient of purity is claimed for the Mangold. On account of the flat, wide spreading foliage, the Mangold beet seems particularly adapted to the beet growing states of the Union where rain is often wanting at the right time in summer.

Of course, there is no variety of sugar beets, which might be said to be suited to all conditions of soil, climate, etc. In different soils and under different treatment given varieties will show different results, nor is it safe to take the experience of one locality as applicable to all and any localities. Thus it has been found that the results of certain varieties raised in European beet-growing localities, as compared with the results obtained with identically the same varieties and in similar soils in this country differed very largely, both as regards percentage of sugar and yield per acre.

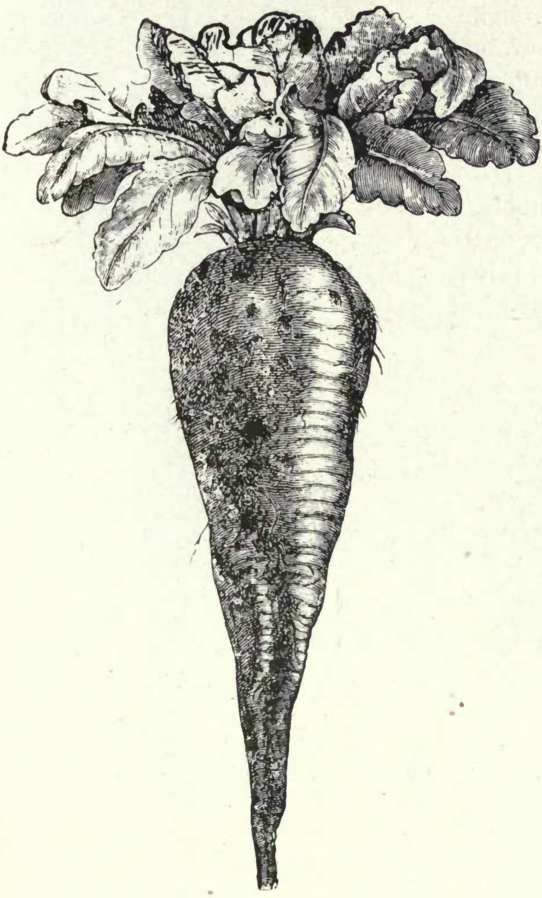


Fig. 4.
MANGOLD.

The only sure and practical way for our beetgrower is to ascertain by actual experiment which varieties are best suited for his lands.

STRUCTURE OF THE BEET AND ITS CHEMICAL COMPOSITION.

Internally the beet root is built up of a large number of concentric rings formed of a much larger number of small cells or cylinders, each of which is filled with a watery solution of several substances other than sugar. Fig. 5 shows a cross-section of a beet cut diametrically. The cells contain a number of crystalloid salts, such as the 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. Figure 6 (reduced from Bulletin 27 of the Department of Agriculture) represents a cross-cutting made lengthwise through the middle of a beet, showing the alternate rings of compact portions and those more translucent, the former containing rather more sugar, and the latter more salts and albuminoids. A large number of nitrogenous bodies have been identified in the beet by various chemists.

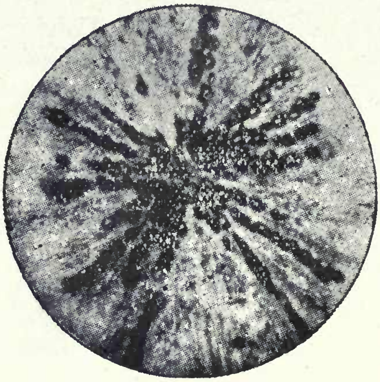


Fig. 5.

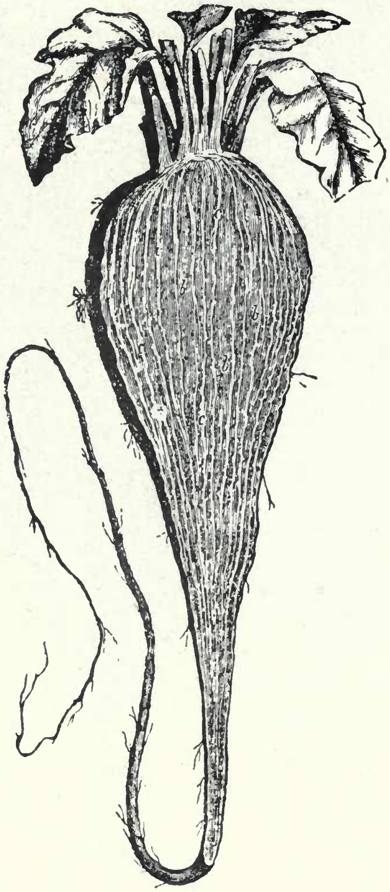


Fig. 6.

CROSS-SECTIONS OF A SUGAR BEET.

Ed. Urbain, a French authority gives the distribution of nitrogen in the beet from his analyses as follows:

	Per cent. in the Beet.	Per cent. of the Total Nitrogen.
Total Nitrogen	0.198	.. ..
Nitrogen of insoluble proteids	0.012	6.06
Albuminoid Nitrogen	0.063	31.81
Nitric Nitrogen	0.050	25.25
Amide and Ammoniacal Nitrogen	0.069	34.84
Loss	. . ..	2.04
		100.00

DISTRIBUTION OF SUGAR IN THE BEET.

The distribution of sugar is not uniform throughout the beet, but varies materially in different parts of the root, as is shown in the diagrams, Figs. 7, 8 and 9, after Slassky.

On basis of experiments it is safe to assert that the percentage of sugar present in the beet increases from the top downward. The lower or smaller part of the beet generally has a larger percentage of sugar than the upper larger part. The crown or neck of the beet, *i. e.* that part of the beet between the base of the leaves and the transverse line showing in a vertical section of the beet and transversing it from a point just below the outermost row of leaves, not only contains less sugar, but is also of lesser purity. This is due to the fact, that such crown has been exposed to the action of the light and air without protection, except that furnished by the leaves.

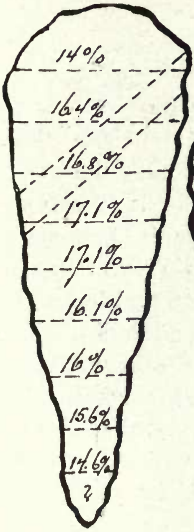


Fig. 7.

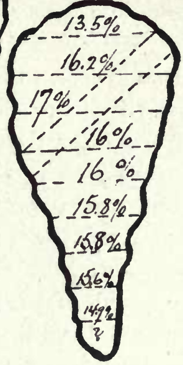


Fig. 8.

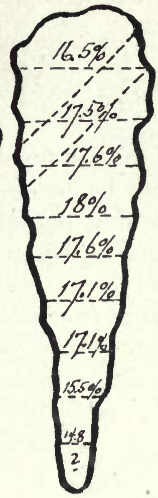


Fig. 9.

It will readily be understood that in beets well protected by heavy foliage, or grown almost entirely under ground, the difference in sugar percentage and purity of the crown as compared with the other part of the beet will be much smaller. The crown on top of the beet grown overground, especially when unprotected by very heavy foliage, being unfit for factory purposes, the beet grower will at once see the importance of aiming to prevent the overground growing of the beet as far as possible.

In this connection the following quotations from authorities on beet culture relative to "*Ratio of Beets to Tops*" may be of interest.

LEWIS M. WARE states in "*The Sugar Beet*":

> "As a general thing it is admitted that the weight of the leaves in a given crop is about equal to one-half that of the roots, and one-fourth to one-third for beets containing 8 to 9 per cent. sugar."

DR. WILEY quoting from MCMURTRIES' report, says:

> "CARENWINDER and CONTAMINE find that there is a relation between the size of the leaves and the richness of the roots; that roots which bear leaves of broad surface, are generally more rich in sugar, than those having small leaves upon a contracted top and those facts are confirmed by an analysis of subjects taken from the same field."

SIZE AND SHAPE OF BEETS.

Small beets as a rule 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 Fabr. d. Sucre*" says:

> "The size of the beet is the inverse ratio of its sugar and salts; the contents of water increases with the size and the weight of the beet."

In very large beets, weighing more than three pounds, the sugar percentage and the purity will be too low to secure the best results, while beets of much less than one pound weight, although their sugar percentage and purity may be high will give too low a yield to make them profitable. Very small beets besides are objectionable to the factory inasmuch as they are apt to give extra trouble and labor. The aim of the beetgrower therefore should be to produce a medium sized beet, which will give the largest possible yield of pure crystallizable sugar per acre. A small beet, irregularly shaped, with so-called fingers and toes, or with prongs running out from the side, or with a tap root more or less subdivided into small roots, due to shallow culture or insufficient cultivation or damaging of the beet during cultivation, is particularly objectionable to the factory. Such beets are difficult to clean, they are apt to cause stoppage in the beet flues, the washers, and by carrying sand or small stones into the slicers, cause unnecessary wear of the knives.

The following is from a report of 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 sideroots 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 34 centimetres (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.
> 5. 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.

DR. WILEY in *Farmers' Bulletin*, No. 52, draws attention to the position of the beet in the soil, in the following words:

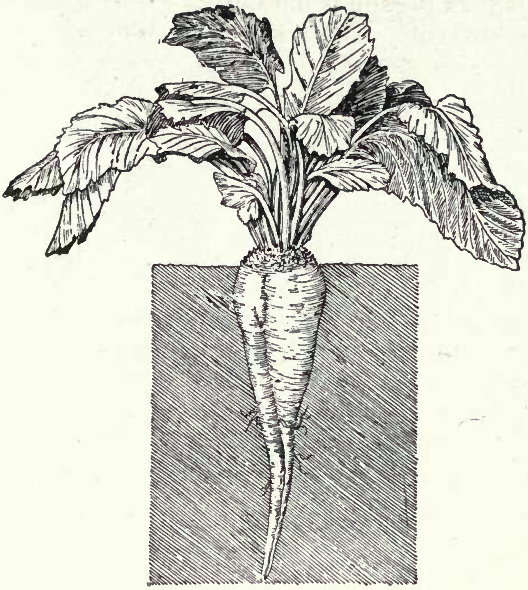


Fig. 10.
POSITION OF BEET IN THE SOIL.

"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 Figure 10.

This position can only be secured for the beet by growing it in a soil sufficiently pervious to permit of the penetration of the top root to a great depth. It is for this reason that subsoiling in the preparation of a field for the raising 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. 11 and 12. 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 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 two-fold advantages for sugar beets: Firstly, it permits the beetroot to penetrate deep into the soil, and secondly, because beets grown in such soil are easily harvested without great loss by what is called "tare"; in other word 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 trained, for although the beet requires an abundance of moisture, yet it does not thrive in wet soils. Very light sandy soils, heavy clay soils and Alkali soils should likewise be avoided. Black Alkali soils are particularly objectionable. Young beet plants cannot survive where there is any percentage worth mentioning of black Alkali or Sodic Carbonate in the soil. White Alkali if not present in too large a percentage in the soil is not hurtful as far as the sugar content of the beet is concerned. It has been proven by experiments, that in a soil containing as much as 0.10 % of sodic carbonate, beet seed will germinate freely, on the other hand, that it is doubtful whether any young plants can survive when the stated percentage of 0.10% of this salt is contained in the soil. Sodic Sulphate does not affect germination to such a degree as the carbonate and the seed will germinate freely, even where this salt is equal to 0.80 % of the air-dried soil, but it is injurious when present in large quantities. Where both the sodic carbonate and sodic sulphate are present in a soil in equal quantities, the action of the carbonate or black Alkali is only slightly or not at all counteracted.

Magnesic sulphate retards, but does not prevent germination, when present in quantities equal to one per cent. of the air-dried soil.

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

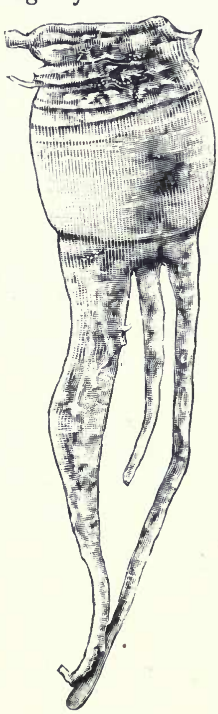


Fig. 11.
IMPROPERLY RAISED BEET.

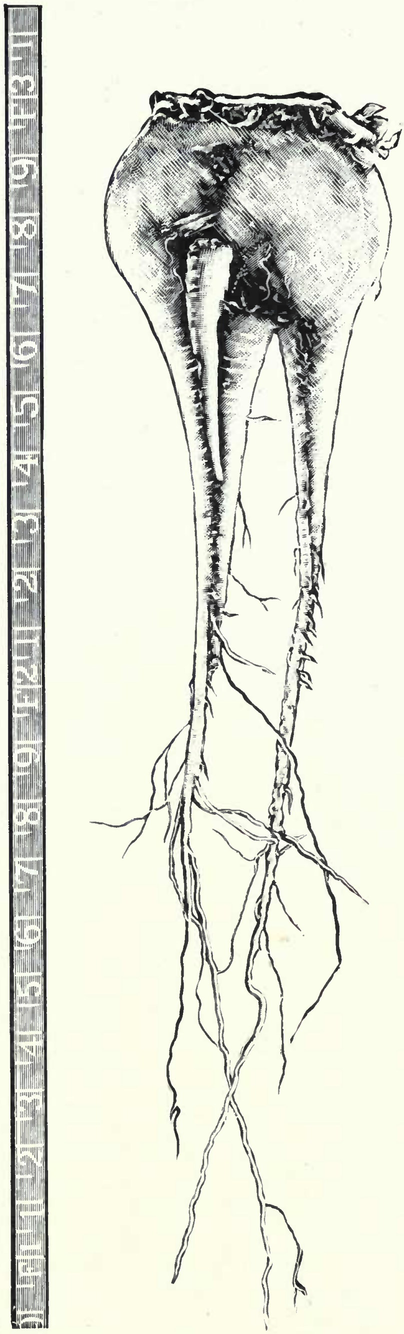


Fig. 12.
IMPROPERLY RAISED BEET.

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 intented for beetgrowing has never been cultivated before it must be thoroughly exposed to air and light, otherwise the crop would prove a failure.

PROF. E. M. SKEATS of the New Mex. Experiment Station in a very interesting report enumerates the following established facts and laws relating to sugar beet development:

1. Most recent researches show that production of sugar is the effect of light more than heat and that it is developed best after a maximum development of root when root growth is at rest.
2. Development of sugar beets takes place fastest under normal heat and light, when there is a maximum of soil moisture and a maximum of air moisture.
3. Abnormal heat, as well as abnormal cold check development and tend to make the plant run into seed the first year.
4. The beet requires for its development a certain amount of heat, which can be found, by adding up the mean temperature of each day, from the date of sowing to that of maturity. Normal heat for the beet is about 3000 degrees Celsius, and this is spread over about six months.
5. For every 100 degrees of heat, the beet requires so much moisture:

For first period of two months:	0.6 inches
" second " " " "	0.4 "
" third " " " "	0.4 "

   and it is very important that these proportions of moisture to heat are in the above order. The above gives a total for normal heat of 12½ acre-inches for the crop.
6. Beet seed to sprout requires about 120° C. units of heat and soil must contain from 7 to 17 per cent. moisture at depth of seed. It will sprout at a temperature a little above freezing to 35°C. (= 94° F.) Best temperature is 20° C. (= 70° F.)
7. As for soil composition:
   a) Phosphoric acid is absolutely needed in sufficient quantity and more increases sugar.
   b) Magnesia appears next important to phosphoric acid.
   c) Lime next and great quantities, and even up to 50 per cent. are not hurtful.
   d) Potash is needed, but soda can replace most of the potash and it is said with great advantage as regards purity.
   e) Nitrogen, little is required and much is decidedly hurtful to sugar production.

CLIMATIC CONDITIONS.

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. 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 of 70° F. This line is called the isotherm of 70°. 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 land where the beet is most likely to be successfully grown. This portion of land is commonly called the sugar belt.

The special report lately published by the U. S. Department of Agriculture gives a very exhaustive and comprehensive explanation

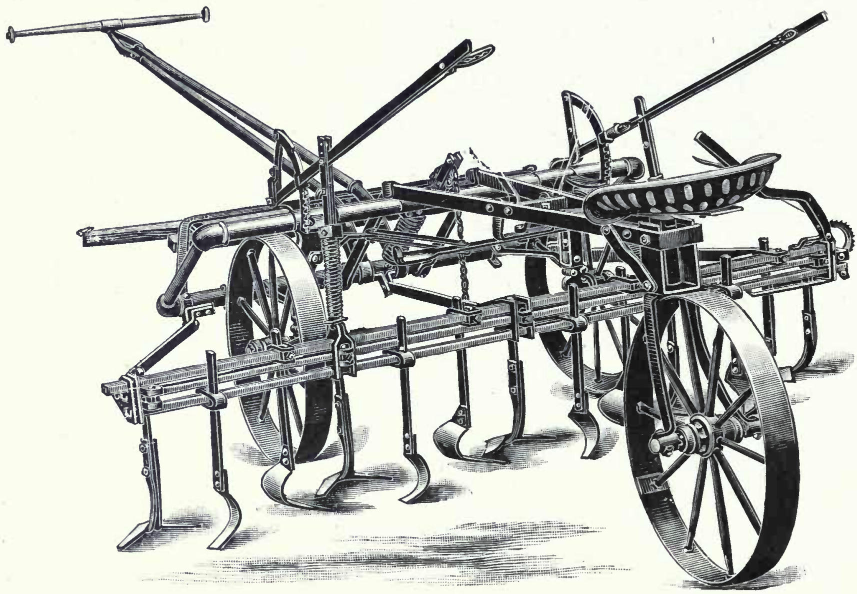


Fig. 13.
FOUR ROW BEET CULTIVATOR.

under the heading of "Climatalogy," the study of which is recommended 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 course, it must be understood that the area adapted for beet culture is by no means limited to this belt. There are many locations outside of it which are extremely well suited to beet culture, while, on the other hand, some of the lands included in the belt would not do for beet raising at all. The map simply is meant to indicate in a general way that area where soil and climatic conditions can be found specially adapted to the sugar beet.

Dr. Wiley, in Farmers' Bulletin No. 52, says as to the extent of the sugar beet belt proper in the United States.

> "Extending a distance of 100 miles on each side ot this isothermal line is a belt which, for the present, may be regarded as the theoretical beet sugar area of the United States. There are doubtless many localities lying outside of this belt, both north and south, in which the sugar beet will be found to thrive; but this will be due to some exceptional qualities of the climate or soil, and not to any favorable influence of a higher or lower temperature. A mean temperature of 70 ° F. in the summer, however, must not be regarded as the only element of temperature which is to be taken into consideration. In those localities where the winters come early and are of unusual severity will be found greater difficulties in the production of sugar from the sugar beet than in those localities where the winters are light and mild, although the mean summer temperature of both localities may be represented by 70 ° F. As an illustration of this difficulty may be cited northern Nebraska and South Dakota, where the winters are of great severity, and Southern California, where there is scarcely any winter at all.
>
> "The mean summer temperature of these localities is about the same, but the continuation of a semi-summer temperature through the winter in Southern California greatly favors the growth and maturing of the beets. In Northern Nebraska and South Dakota the beets, which are to be manufactured in the winter time, have to be protected by expensive silos. In Southern California and other places similarly situated the beets can be protected without any covering, or at most with only a slight covering of leaves or straw. The season for planting in a mild climate is also longer. For instance, in Southern California planting can commence as early as January and continue till June, thus giving a beet crop coming continuously into maturity from the 1st of August to the 1st of December. In other localities the planting must be accomplished in a short time, say from the 10th of May till the 1st of June. Before the first of these dates the ground will be too cold for planting and after the second the season will be so late as to prevent the maturity of the beets before frost. When the field is properly plowed and subsoiled in the late autumn the farmer will be able to take advantage of the first favorable opportunity in the spring to prepare the surface of the soil and plant the seed."

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 twenty-five inches, and thirty inches would not be an excessive amount. This rainfall should not be less than two inches, nor more than four inches per month. Of course 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, or the soil is of that peculiar nature that it will allow subterranean moisture to reach the rootlets of the plant, 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.

Just as important as rainfall is sunshine at proper seasons. A dry fall is the most favorable for proper ripening of the crop, and 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 ALLOTED 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, deep-rooted plants interchanging with short-rooted ones, cereals with leafed plants, and arranged in such a manner that the cereals, grasses and vegetables 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 in 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, I would always favor a rational rotation.

It stands to reason that successive raising of beets on the same piece of ground must produce crops gradually decreasing in quantity and quality, and that this will be the case the sooner and in a more marked manner the less fertile the ground by nature. I would always favor, and it will be found more advantageous to utilize the ground, after having grown beets on it at least one year for another crop.

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 I understand is much practiced 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 to be 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, the butts by this time having rotted away.

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.		
1/5 sugar beets.	2/9 sugar beets.	1/4 sugar beets.
1/2 cereals.	4/9 cereals.	3/8 cereals.

D.	E.	F.
1. Winter cereals *	1. Beans, peas, etc.*	1. Pasture.
2. Sugar beets **	2. Sugar beets.**	2. Raps.
3. Summer cereals.	3. Summer cereals.	3. Winter cereals.*
4. Clover.	4. Sugar beets **	4. Sugar beets.**
5. Winter cereals.*	5 Summer cereals.	5. Summer cereals.
6 Sugar beets.**	6. Clover.	6. Clover
7. Summer cereals.	7. Pasture.	7. Winter cereals.*
8 Sugar beets **	8 Winter cereals.	8. Sugar beets.**
9. Beans, peas, etc.	9. Sugar beets.**	
3/9 sugar beets.	3/9 sugar beets.	1/4 sugar beets.
4/9 cereals.	3/9 cereals.	3/8 cereals.

In the aforementioned rotations summer cereals might be displaced by potatoes, beans, peas or summer vegetables.

In the beet sugar districts of France a more simple rotation is generally practiced 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 so-called four-field plan. From this, as from any other plan, bottom lands, moory 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 crops, 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.

---

*With stable manure.

**With artificial fertilizer.

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.

The beet grower will do well to thoroughly study the effect of preceding crops, for there is no question that the crop grown on a piece of land during the year previous to its being used for beets to a considerable extent influences the quality and yield of the beet crop. The reason is plain enough: Different crops take from the soil such ingredients of fertility, and in such proportions and quantities, as they require for the elaboration of their plant tissues, roots, foliage, etc.; hence the soil is correspondingly depleted of these ingredients. Again, different crops vary considerably in their fertilizer requirements, as also their methods of growth, character of root system, etc., hence a particular crop will give a better yield when preceded by some crops than by others.

FERTILIZATION.

One of the great advantages most of our soils offer to the intending beet grower is their natural fertility. The German and other European beet growers start with a cost of from $10.00 to $15.00 per acre for fertilizers, while our farmer, if he cultivates his land properly, will not have to figure on such a heavy expense in this respect. The contention, however, frequently expressed by farmers who have never raised any sugar beets, and even by 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, is certainly wrong and misleading. Any farmer who has studied the rudiments of the subject of plant feeding will readily understand that each crop that is raised upon a certain piece of ground removes so much of the plant food available. Now, if the soil was originally very rich it can stand the drain longer than a soil which originally contained only a small supply of plant food. But, in either case without fertilization the soil would become exhausted sooner or later. 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. These constituents to some extent may be provided by the previous crop. For instance, legumes, such as clovers, beans, peas and vetches have the peculiarity of absorbing a vast quantity of nitrogen from the air and enriching the soil with this essential plant food ingredient. However, such part restoration of the fertility of the ground is not sufficient, and 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.

The above mentioned constituents are contained to a considerable extent 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 the quantities of the aforementioned constituents in 1,000 pounds of beets and beet leaves as follows:

CONSTITUENTS.	ROOTS, lbs.	LEAVES, lbs.
Potash	3.3	6.5
Phosphoric acid	0.8	1.3
Magnesia	0.5	3.0
Nitrogen	1.6	3.9
Total ash	7.1	18.1

These figures speak for themselves and show the wisdom of not removing leaves from the field unless fed to stock and returned as solid or liquid excrement to the soil.

Dr. Wiley's own comment is as follows:

"It will be seen from the relation between the roots and leaves that for equal weights the amounts abstracted by the latter are considerably greater and deserve especial consideration in case the leaves are needed for cattle food. From this point of view the leaves should be left in the field. It is certain that otherwise complete restitution is attended with some difficulty. The form in which the above mentioned plant constituents shall be returned to the soil is well established for phosphoric acid and magnesia, and partly for nitrogen. Superphosphates, with greater or less content of phosphoric acid, or with addition of a nitrogenous element, and basic phosphatic slags, are of universal application. As has been shown by direct investigations, the magnesia is nearly all returned in the press cakes from the factory, though a more uniform distribution than is thus secured is much desired.

"The soil ingredients most essential for the successful production of sugar beets are nitrogen, phosphoric acid, potash, lime and magnesia.

"Most soils contain a sufficient quantity of magnesia, and the press cakes from the factory, which should be returned to the soils, will supply any deficiency. The same is true in regard to lime, although there are some soils in which the supply of lime is naturally deficient. Such soils would be benefited by an application of land plaster, burned lime, phosphatic slags or ground shells. Phosphoric acid and potash are supplied in the form of ordinary commercial fertilizers, the phosphorus as ground bone, superphosphate and basic slag, and the potash as kainite or other salt. Of the various potash compounds found in natural deposits all are useful. Preference is due only to compounds with organic substances. Consequently the molasses, or its residue after distillation, and the liquors of the molasses working processes, all rich in potash, are themselves very valuable materials for potash fertilization, and should be carefully preserved for such use. It must not be supposed, however, that the demand for potash will be satisfied by returning to the soil the molasses from the crop of beets in the form of waste products. Aside from the leaves, for which if taken from the field a largely increased potash return must be made, the molasses itself does not represent the entire amount of potash taken. Factories which produce raw sugar sell with it also potash, and in all factories the waste waters carry away potash compounds sufficient to account for the difference between the amount of potash in the beets and in the molasses.

"Phosphoric acid is best supplied in the form of ground bone, superphosphate or basic slag from steel factories.

"Nitrogen may be supplied in the form in which it exists in ground bone or from the refuse of the slaughter houses in the form of dried blood and tankage, or as cotton seed meal or oil cake, or as nitrate of soda, sulphate of ammonia, etc. The simultaneous application of stall manure and nitrate of soda is not advisable by reason of the possible loss of nitrogen due to the development of denitrifying ferments.

"As to the relation which the quantity of material returned to the soil should bear to the quantity abstracted by the beet, it may be said in general that it is desirable to return as much nitrogen, from one and a quarter to one and a half times as much potash, and two and a half times as much phosphoric acid as have been removed by the roots. Greater additions of potash and phosphoric acid have no disadvantageous effects upon the crop. Direct investigations in regard to the relations between the sugar and potash in consecutive crops for many years have failed to give the least ground for a contrary conclusion. But it must not be expected, on the other hand, that increasing fertilization, especially potash fertilization, will produce proportionately increasing crops, as has been asserted by some.

EFFECT OF NITROGENOUS MANURES ON THE QUALITY OF THE BEET.

"The opinion has generally prevailed among beet growers during late years that heavy nitrogenous manuring, especially with nitrate of soda, produces no injurious effect on the quality of the beet. This opinion was based on the fact that in such beets the sugar per cent. was only slightly diminished. Nevertheless, the quality of a beet may be impaired even with little or no diminution of the sugar content by reason of the increate of the percentage of nonsugars present.

"In this respect it has been shown that heavy manuring with nitrogenous substances greatly injures the quality of the beet for sugar making purposes. The apparent coefficient of purity of the juice is also frequently misleading, since no account is taken of the nature of the nonsugars present.

"The real purity of the beet is also to be distinguished from the apparent purity of the juice. The real purity of the beet is obtained by dividing the percentage of sugar in the beet by the total solid matter in solution therein; the apparent purity of the juice by dividing the percentage of sugar therein by the apparent percentage of solids as indicated by the specific gravity. Judicious fertilizing with nitrate of soda, however, is beneficial, and this form of nitrogenous fertilizer is in many respects the best known for beets."

It stands to reason that a soil to which the aforementioned 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 must, 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 must depend, of course, on the richness of the soil, and the experienced farmer is the best judge in the matter, and in most cases the question can only be solved satisfactorily by systematic experiments.

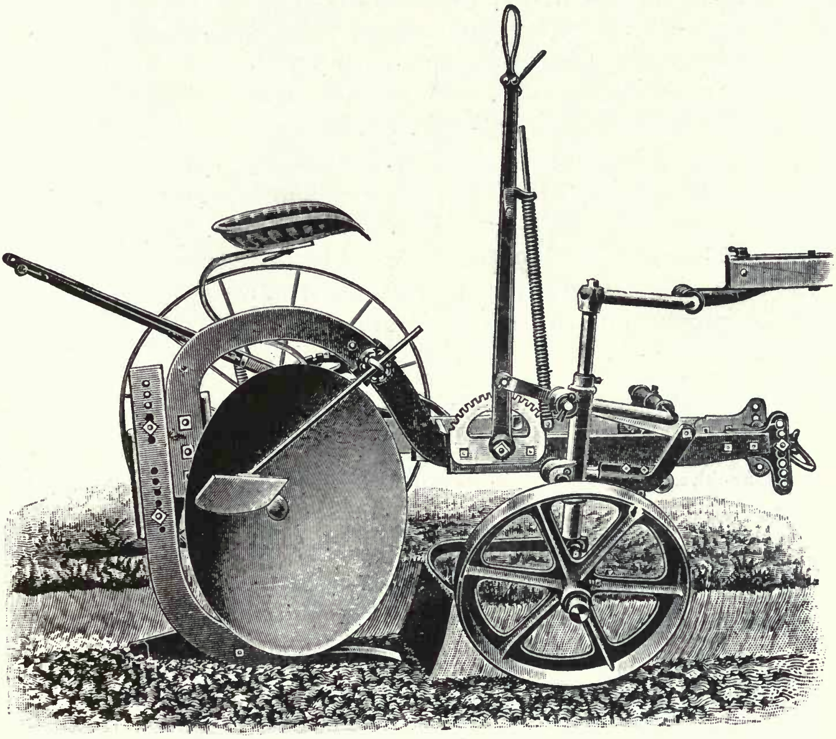


Fig. 14.
GANG PLOW WITH SUBSOILING ATTACHMENT.

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. Poor soils may be brought up to the required standard of fertility by applying the fertilizer for several years in succession.

Manures, as well as slow-working fertilizers, should be applied gradually instead of by one heavy application, which would be apt to produce overgrown beets of impure quality, inferior for purposes of sugar making.

The manure used must in any case be well rotted, and 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, apt to be rejected by the factory

Raw stable or barnyard manure is inferior to well-rotted manure. Sheep manure should never be used in the beet field, as it has positively an injurious effect, as proven by the experience of European beet raisers. *The application of any raw manure must be avoided* in the beet field. As already said, if the beet field is to be manured it should be done in the fall, with well-rotted manure, but much the better method is to give the stable or barnyard manure to the preceding crop. In this way the organic matter, which these manures supply so abundantly, will have ample time to oxidize in the ground before the beet crop is grown.

Of commercial fertilizers nitrate of potash, nitrate of soda, muriate of potash and sulphate of potash, dissolved phosphate rock and lime. sulphate of ammonia, dried blood and tankage 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, for instance, are recommended by experienced growers:

Two-thirds muriate of potash and one-third sulphate of potash.
Two-thirds muriate of potash and one-third sulphate of potash and lime.
One-third muriate of potash and two-thirds sulphate of potash.
One-third muriate of potash and two-thirds sulphate of potash and lime.
Sulphate of potash and lime.
Muriate of potash and lime.
Dried blood, bone meal and potash.
Muriate of soda, dried blood, acid phosphate and potash.

The subject of fertilization is one of the greatest importance to the farmer, and many failures in beet raising are solely due to an utter disregard of the importance of the subject on the part of farmers. The sugar beet makes greater demands to fertility in the soil than most any other crop. While cereals grown on poor soil give a small yield, the quality of the crop generally is not so much inferior than when the cereal is raised on fertile land. The sugar beet, however, under similar conditions, not only gives a small yield, but also the sugar content of the beet is at once lessened, and has been shown in instances to be less than half of what beets tested grown from the same seed on rich land. Farmers sometimes raise grain on land for years without application of any kind of manure or fertilizer, until the land does not produce any longer a paying cereal crop. They then turn their attention to sugar beets, expecting to find this crop a means of making the land pay. A more fatal mistake could not be made. It cannot be stated too emphatically that beets of good quality and purity cannot possibly be grown on soil whose fertility has been almost exhausted through continuous grain raising, or other crops, unless some of the fertility taken away by such crops be returned to the soil in the form of manure or fertilizer. Many of our farmers are adverse to using commercial fertilizers on account of the cost. But while this cost might prove too big an item in con-

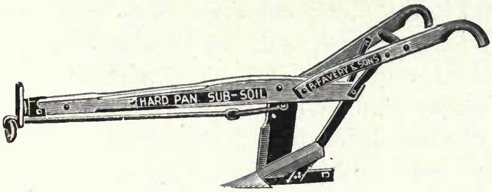


Fig. 15.
HARDPAN SUBSOIL PLOW.

nection with cereal and similar crops, it will always prove a paying investment in connection with a sugar beet crop. No matter how worn out a soil may be, if otherwise suited for sugar beets, by the judicious application of manure and fertilizers it can be made to produce sugar beets fully up to or even exceeding the factory standard of sugar content and purity, and at the same time to yield a good tonnage per acre. It is solely due to a lavish application of commercial fertilizers, besides stable or barnyard manure, that the European beet raiser is enabled to produce fine crops of sugar beets on soils which have been under cultivation for half a century and longer. He would as soon think of growing sugar beets without plowing and cultivating the land as without the use of artificial fertilizers and manure. In concluding this chapter I have to draw attention to the value of the refuse lime of the sugar factories as a fertilizer. In the process of sugar manufacture large quantities of lime are used. It finally leaves the factory in a pulverized or soft state, and for most of our factories it is a waste, while in the European beet raising countries it is eagerly sought after by the beet growers as a fertilizer. Of course its value as such varies according to the amount of water it contains. Much of the lime in this waste is of about the same chemical composition as found in water-slacked lime, while part of it is present in the form of carbonate of lime, and the longer the waste has been exposed to the air the greater the quantity of the latter. This waste contains also, usually, a certain percentage of nitrogen, phosphatic acid and potash, which add to its value as a fertilizer.

It should never be applied in a wet state, as it would then cake, thereby preventing a thorough amalgamation with the soil. The best method is to take it to the beet fields in the fall, distributing it in small piles, and allow it to lie there until spring. Through the effect of the freezing during the winter it will reach the proper condition for spreading it and working it into the soil. Some of the beet growers in Europe store this material in large piles, which are worked over in intervals of a few weeks, which process after a couple of months gets it in a fit condition for use.

CULTIVATING THE SOIL—SUBSOILING, PLOWING.

Plowing of the beet field should be begun as early as possible in 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 the 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 fifteen or sixteen inches, or as deep as the subsoil plow may go. This is of great importance, because it enables the beet to penetrate into the subsoil without much obstruction, thus preventing it from growing out of the ground and allowing it to extract considerable nourishment from the lower soil. However, the sixteen 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, and, as is customary for grain, viz.: five inches, and the maximum of plowing required in a good worked beet field, care must

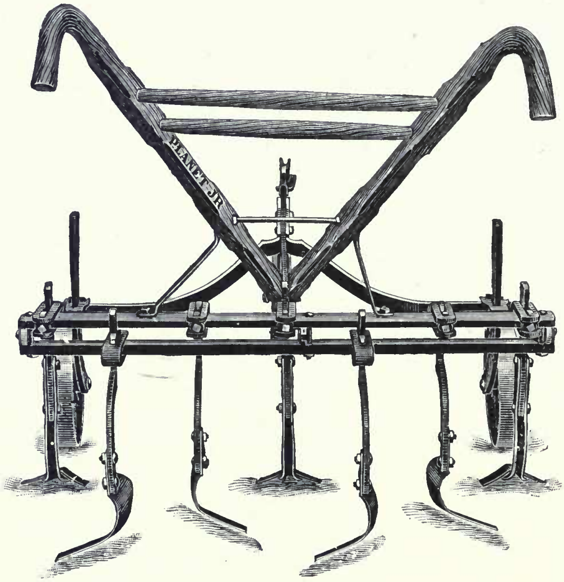


Fig. 16.
TWO ROW BEET HORSE HOE.

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 this uncultivated soil should be taken out, *i. e.*, besides the four or five inches of 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 spring, *i. e.*, as soon as the frost is out of the ground and the ground dry enough to prevent sticking. This for the following reasons: First, because the sooner the weeds are encouraged to grow the more of them can be killed before planting; secondly, because ground plowed while the weather is cool will retain the moisture much longer than it will if plowed during warm weather; and, furthermore, because it is much better to allow the ground to settle as much as possible after plowing and before preparation of seed bed, so that it will become thoroughly packed, thereby insuring better and quicker germination.

A gang plow with subsoiling attachment (such as shown in Fig. 14) is now used where large areas are to be cultivated. If the grower cannot afford to buy one he may use a subsoil plow of the type shown in Fig. 15, to follow the furrow after the first plowing by ordinary plows. In case of need any ordinary plow can be used for subsoiling by taking off the mould-board and having the blacksmith put on a couple of pieces of round iron in its place that will raise the subsoil and allow it to drop back into the bottom of the furrow.

After spring plowing harrow, or, better, float once immediately and then leave the ground as it is until the time to prepare the seed bed, thus allowing the weeds to sprout. If on the piece of ground intended for the beets corn has been grown the previous season, it is absolutely necessary to take the stalks and roots out of the ground in order to permit of easy and proper horse cultivation. It would not do to plow them under, as in cultivating later the cultivator knives would bring stalks and roots again to the surface, and at the same time dragging along with them more or less of the small beet plants. A good plan is to remove the mould-board from the plow, which will make it possible to loosen the roots without turning the cornstalks under. They can then be gathered up with a hay rake into piles, and after burning as much as possible, the remainder be hauled off.

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 the 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.

The cultivator shown in Fig. 17 is well adapted for this purpose. When necessary it can be followed by a harrow and roller. The 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 the planting, say the day previous if not the same day, and for the following reasons: First,

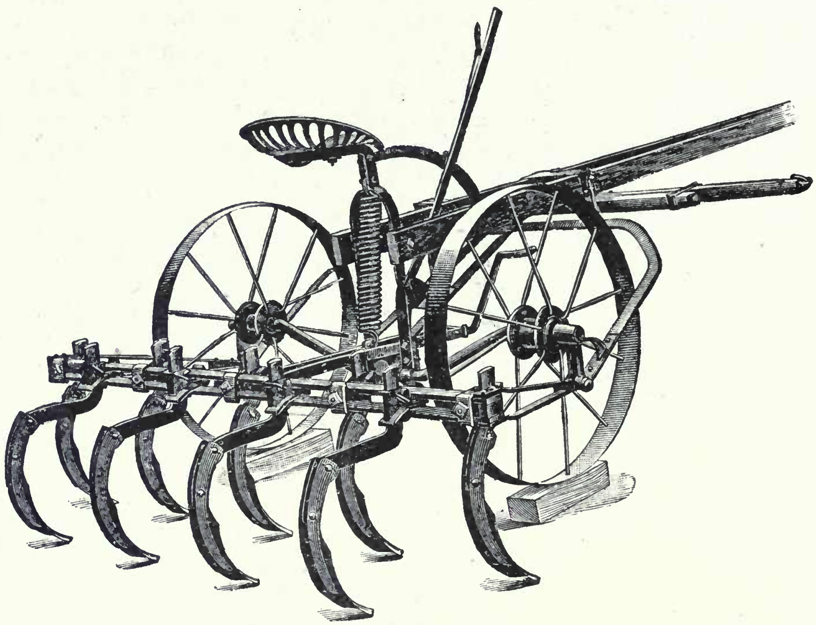


Fig. 17.
CULTIVATOR.

because the seed requires considerable moisture to germinate, and allowing the seed bed to dry out might be followed by serious consequences to the yield; secondly, by preparing the seed bed ahead of planting the weeds would not get a good start.

In dry weather it is absolutely necessary that the seed bed should be prepared and seeded the same day.

To prevent blowing, which is very detrimental to the small beet plants, it is advisable to run a light harrow over the ground after rolling, but before seeding. This harrow must be very light, and can be easily constructed and without much expense by using 2x2 pine pieces for the beams and large nails for the teeth, only letting them project below the beams one and a half to two inches. This harrow must simply scratch the soil, not over one-half inch deep, thus giving a rough surface, which will prevent blowing, except on very dry, sandy soil, on which, for this reason besides others, sugar beets should never be planted. The soil of the seed bed thus prepared must not be loosened again by a deep harrowing, as this would injure the germination.

SELECTION OF 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 me say, *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 seed. It is very difficult to judge beet seed by its appearance. Sugar beet seed is of a shiny brown color and round, slightly flattened on one side. Each seed corn shows in some place a papillary growth, which contains the rootlet of the germ. This outgrowth is more perfect in some seed varieties than in others, and while it is hardly visible in some seeds it is very prominent in others. Seed experts claim that in the best seed this outgrowth or wart is always strikingly visible.

Henry W. Diederich, United States Consul at Magdeburg, in a late report made 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 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 a 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 mother beets, but from the first-class seed mentioned above. This inferior seed, however, is not used by first-class sugar men in Germany, France, Holland and Belgium, but most of it goes to Russia, Austria and the United States.
>
> "And this is why I deem it my duty to call attention to the importance of only getting 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 1 per cent. in sugar content. Now, the second generation of seed will degenerate more than as much again, and lose from 1 per cent. to 2 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 and France, where seed growing has been pursued in many families for three or four generations. They devoted themselves entirely to the culture of beet seed and the purifying and amelioration of the beet race was done 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 properly grown from first-class seed varies between 15 and 25 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 produced.

In Utah some farms were started in 1895 by the Mormons for the exclusive production of sugar beet seed. An American sugar beet seed farm has also been started at Los Cruces, New Mexico, and others will undoubtedly follow in short order. The seeds grown on these farms are known under the name of "Utah Kleinwanzlebener" and "Eddy Kleinwanzlebener." From experiments made on a large scale in various States it is claimed that the Utah seed is superior in pure sugar per acre, *i. e.*, that it is superior in sugar and purity to the seed from which it is descended, but a little inferior in yield of tonnage. The seed from Eddy is said not to be far behind in results. It would, therefore, seem that sugar beet seed can be grown in the United States fully equal to the best of the imported varieties. 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 seed growing is one of the most intricate features of the industry, and it will take years of patient study and practice until we shall have established a safe, reliable and sufficient seed production of our own. Until then we shall have to depend upon the old established reputable seed growers of Europe, such as Gehr. Dippe in Quedlinburg; F. Knauer, Groebers; Rabbethge & Giesecke, Kleinwanzleben; Otto Breustedt, Schladen; G. Schreiber & Sohn, Nordhausen; O. Hoerning, Eisleben; Vilmorin-Andrieux & Co., Paris; F. Demesmey, Cysoing, and others.

In selecting the seed soil conditions must, 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 I would advise to give all the best known varieties a trial, and get seed of as many reliable varieties as procurable, sowing in rows, each variety by itself, so that the result can be noted.

PLANTING THE SEED.

The planting of the seed, 20 to 25 pounds per acre, according to soil and climatic conditions, is best done by a seed drill, hand work 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. A single row beet seeder is shown in Fig. 18, while Fig. 19 shows a four row machine. The four runners can be set to plant 16, 18 or 20 inches apart, or any intermediate distance, and can be regulated to a capacity of 15, 20 or 25 pounds of seed to the acre. The depth of planting is regulated without changing the pressure of the press wheels.

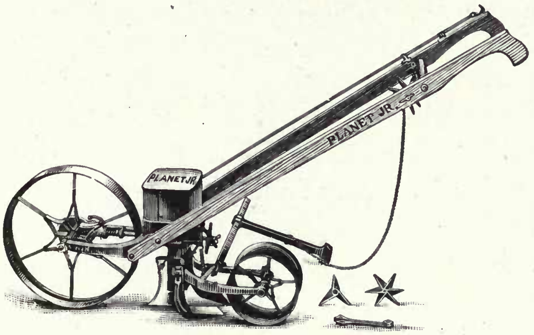


Fig. 18.
SINGLE ROW BEET SEEDER.

It is claimed that seeds planted with machine drills sprout earlier and develop better than those planted by hand. Machine drills, seeding four rows at a time and dropping the seed continuously, will plant ten to twelve acres per day. The hardest part of beet raising is to get a good stand all over the field. Theoretically two to four pounds of beet seed would suffice to make a full stand on an acre of ground, but to get this stand in practise it is necessary to sow a much larger amount. Not less than fifteen or eighteen pounds per acre should be used. 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 rains one plant will help the other to break through. Furthermore, cutworms and other predatory insects would have to be extremely numerous in order to destroy enough of the crop to make it a failure.

The seeds should be planted in rows of from fourteen to twenty inches apart, not deeper than necessary for a thin covering of soil, but, of course, in both respects the farmer must be guided by the richness of soil and climate.

DIFFERENT DATES OF PLANTING.

Tests by the Government stations and private individuals seem to have pretty well established the fact that late planting means generally a poor quality of beets, less weight in tons per acre and less sugar per acre. In most of our localities sugar beets can be planted from early in April till the last of May, this being about as late as it is advisable to sow. Of course, a crop might be obtained from beets sown considerably later, but such late plantings are apt not to ripen fully, and naturally produce less of a crop and not near as much sugar than the earlier plantings.

PLANTING ON FRESHLY PLOWED GROUND AS COMPARED WITH GROUND PLOWED A FEW DAYS BEFORE PLANTING.

By repeated experiments it has been demonstrated and is now generally looked upon as an established fact that planting on freshly plowed ground will insure a larger and better crop. Three or four days between plowing and planting might mean as much as a loss of one-seventh and more of the weight of the crop and a corresponding smaller amount in sugar value of the crop.

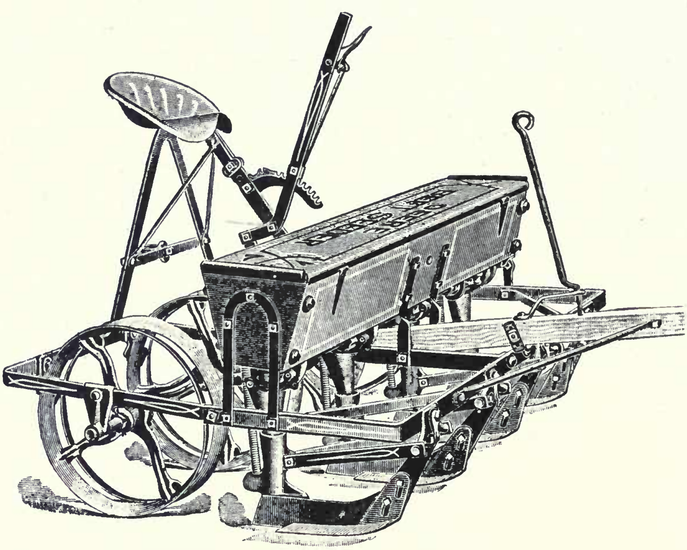


Fig. 19.

Where large areas are to be planted they should be plowed in sections, and each section planted the day of plowing. Farmers growing a large acreage and not having very much help will find it advisable to plant in sections, say from five to seven days apart, which will give them more time for thinning and enable them to economize in labor. However, under no circumstances plant too late, for in that case, especially in an early, dry season, the beets will not be strong enough to withstand the drought. *It would be much better policy to hire help during thinning time than to plant too late.*

DIFFERENT DEPTHS OF PLANTING.

The depth of planting must be made dependent on the condition of the soil. In very damp, freshly plowed ground, especially over a wet subsoil, one-half inch to three-quarters inch depth is as low as would be advisable to sow, but in ordinary dry ground a planting at a depth of one inch to one and a half inches will give a better stand, yield and quality. Deeper 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 or after the drilling, or both before and after, this depends on local conditions. Regular rules cannot be set up for it, but every practical farmer will decide the question for himself. In a light sandy soil it is absolutely necessary to use roller and float so as to compact the soil and to smooth and fill up all horse tracks, so that in drilling there will be no depressions for the drill to dive into. If this is not done heavy rains are apt to wash the sand into the depressions left by the drill, or the wind by blowing may fill them up, burying the seed so deep that it would not come up. As a general rule I 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.

IRRIGATING UP THE SEED.

This is practised in some localities. It is done by making a small furrow some six inches from the seed and letting water run into this furrow until it soaks sideways and wets the seed. In heavy soil and soil which is very retentive of moisture irrigating up the seed is of no benefit and rather detrimental. Such soil bakes easily, and the bad effects of hardening would counteract the good effect of the extra moisture. Where the land is sandy enough so as not to bake, irrigating up the seed will prove beneficial. In very light soils it is almost a necessity, as such soils do not hold enough moisture to insure a complete germination.

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. Under no circumstances must the weeds be allowed to get the start of the beet plants.

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 descernible from the marks of the press wheels. As soon as the plants break through the ground—about two weeks after the drilling—and the rows can be followed actual cultivation must begin.

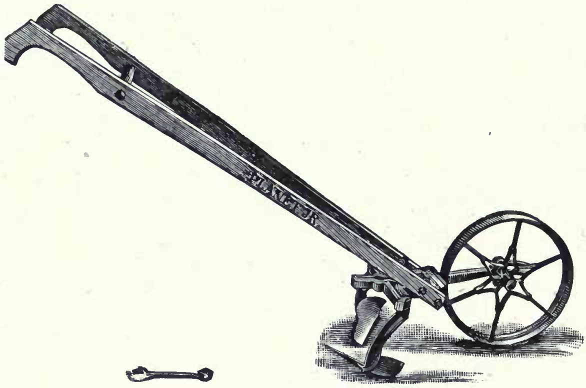


Fig. 20.
SINGLE-WHEEL HOE FOR CULTIVATING BY HAND.

This work is best performed either with a one or two horse cultivator. Figs. 20, 21 and 22 show single-row cultivators. Where four or more rows are to be cultivated at once the implements shown in Figs. 17 and 18 may be used. 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 I 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.*

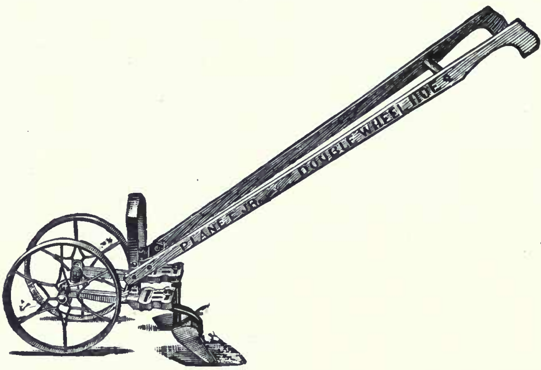


Fig. 21.
DOUBLE-WHEEL HOE FOR CULTIVATING BY HAND.

After the third hoeing the cultivator should be used every eight or ten days, and even oftener, if growing weeds should demand it.

THINNING OUT.

Early thinning out is the main requisite for successful beet raising, and can only be done properly by hand. When the beets have attained some size and show four leaves it is time to commence the thinning.

The thinning out must be done in the most careful and prompt manner, as on it depends in a very large measure the yield and quality of the crop. Every inch of the beet field must be carefully weeded and nothing allowed to be seen above ground save the outward evidence of inward sugar developing growth.

DIFFERENT DATES OF THINNING.

The proper time to do the work is while the plants are very young, as soon as the third or fourth leaf becomes well defined and the root is only a mere thread. If the thinning is delayed too long the plant receives a setback from which it has difficulty to recover.

The thinning out may be extended over a period of at least fourteen days without injury to the crop, and the different dates of thinning within this time would not have any perceptible effect on either the quantity or the quality of the crop.

DIFFERENT DISTANCES OF THINNING.

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 eight inches apart, while in poor land thinning out to ten inches apart is necessary.

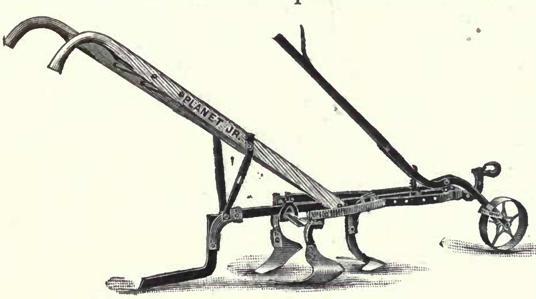


Fig. 22.
SINGLE-ROW SUGAR BEET HORSE HOE.

It is generally contended that beets eight to ten inches apart turn out poorer in quality than those growing closer together, and that if the stands are equal more tons per acre will be raised at less than eight inches apart than at over this distance.

The rows should first be spaced or bunched, which is done with an ordinary four or six inch hoe, cutting a four or six inch bunch of beets out and leaving about a two-inch bunch, which will contain several plants, all of which are removed by hand pulling except the strongest plant. The best way to thin for a person is resting on his knees to go over the row, selecting the best beet and holding it down firmly with the thumb and finger of the left hand, while a quick move of the right hand pulls up all extra beets and weeds remaining. The ground must be pressed firmly around the remaining plant If timely thinning out is neglected the roots become entangled, making the thinning detrimental to the plant that is left.

One person can thin an acre of beets in about four days, hence a given acreage can be thinned out at the rate of one person to each three or four acres. 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 large 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 leaves the remaining one in weak condition, which is not the case while only beginning to send its roots into the ground.

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

TRANSPLANTING BEETS.

This can only be practiced by setting the beets into running water. It is a method requiring so much care that it has usually not been found to pay.

WIDTH OF ROWS.

As to the distance from beet to beet, I 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 1½ to 2 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=144 inches square per each plant.

One square yard equals 1,296 cquare inches, or 144 : 1,296=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 six beets for each square yard.

One acre contains 4,840 square yards.
Six beets per yard at 1 pound equals 6 pounds.
Six beets per yard at 1½ pounds equals 9 pounds.
Six beets per yard at 2 pounds equals 12 pounds.
Therefore, Per acre at 6 pounds per yard we receive 14½ tons.
Per acre at 9 pounds per yard we receive 21¾ tons.
Per acre at 12 pounds per yard we receive 29 tons.

TONNAGE PER ACRE.

From the foregoing it will be seen that the raising of ten to fifteen tons per acre should be easily accomplished with good tillage and tolerably 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 ten and fifteen tons, although in many localities farmers have raised a good beet with a tonnage as high as twenty-five tons and more 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 favored sections may do better, but the aforementioned percentage is a fair estimate of the average.

I may here refute a prejudice often found among farmers who have never before raised sugar beets. They have probably heard of the so-called "beet weariness" of beet fields in Germany and fear the same condition may make itself 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, superphosphates, etc., are used. This subject requires no consideration where only a reasonable percentage of the areable land is used for beet culture.

To the contrary, *the longer a field will be under rational beet culture the larger must be the crops, not only in beets, but also in the grain following them.* This has been found correct in Europe during fifty years of observation, and the same conditions will result in this country.

MATURING OF THE BEET. HARVESTING.

The harvesting of the 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 harvested 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 sometimes 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 (Fig. 23), which is driven so that the prongs come on opposite sides of the row, lifting the beets a short distance and completely loosening them, but leaving them in the ground.

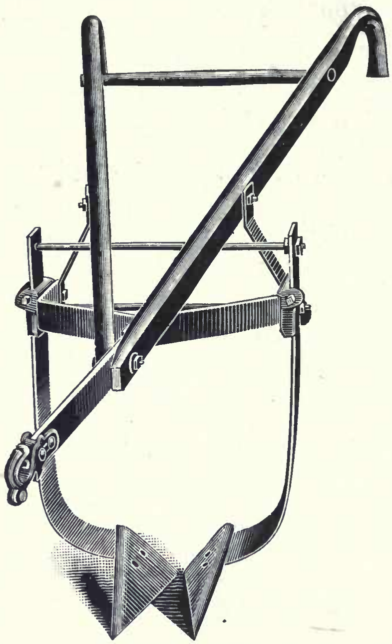


Fig. 23.
BEET LIFTER.

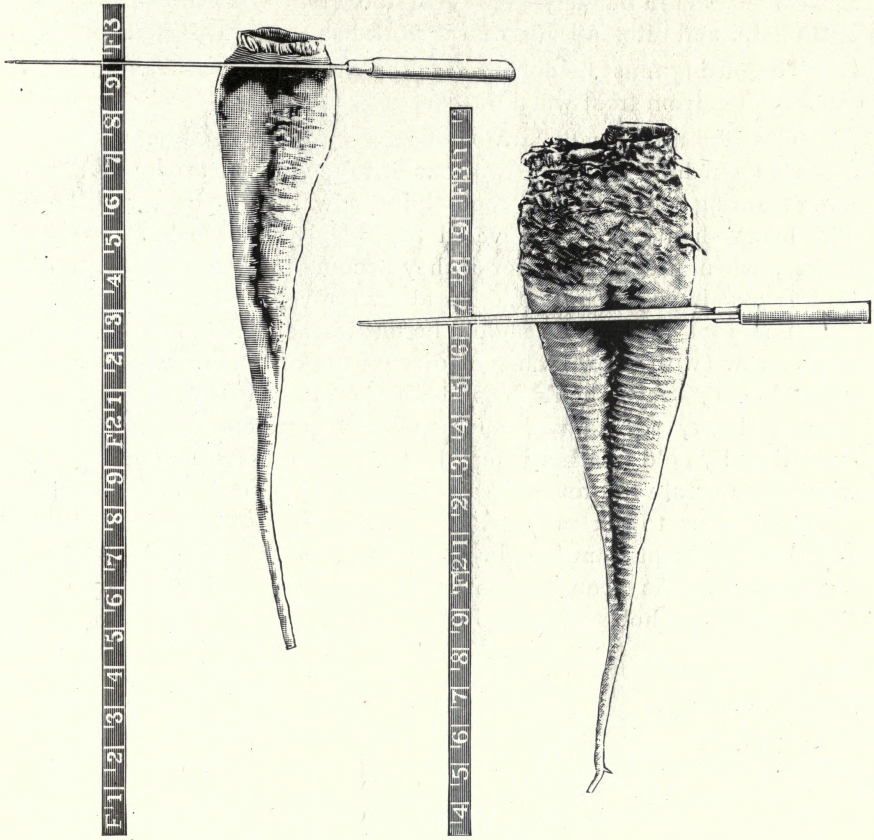
The beets are then easily lifted out of the ground by means of their leaves. This work is mostly done by hand, as also the topping, which is the next operation in order.

I 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 been loosened by the puller and partially lifted out of the ground the topper grasps it by the leaves and lifts it with the left hand from the ground, while with the right hand he removes the crown or top of the beet by one blow, cutting just at the base of the bottom leaf.

This is done by a knife made expressly for this purpose, but a strong, well riveted butcher knife with a ten-inch blade will perform the work as well. Fig. 24 shows a properly capped beet. Fig. 25 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 objecttionable mineral salts absorbed by the beet in its growth accumulate in the top, particularly in that portion grown above the surface. These



Figs. 24 and 25.

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, and they are simply put into piles and the tops thrown over them as a protection from the sun or frost.

Beets should only be pulled during the early part of the season as fast as the factory can use them. At the end of the season, where there is danger of the ground freezing, all of the crop should be harvested and either delivered to the factory or siloed in the field where grown.

PITTING—SILOING.

As beets shrink considerably if shipped in warm weather, it is advisable for the farmer to pit them and not to ship to the factory until 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 no less than two tons of topped beets are placed, making a slanting pile with 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 lose 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.

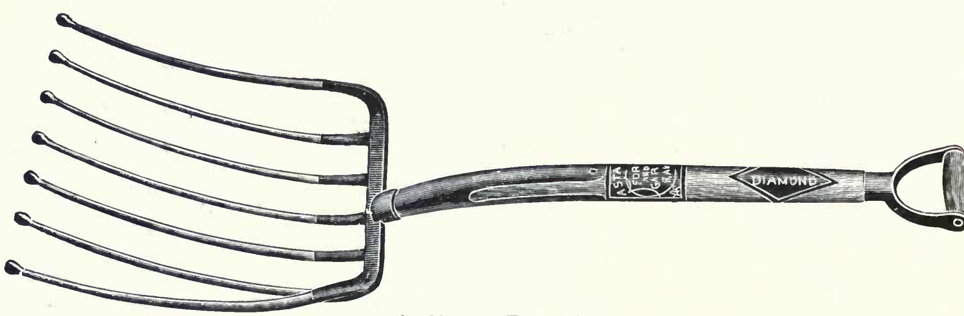


Fig. 26.—BEET FORK.

For the handling of beets a beet fork, such as shown in Fig. 26, with solid steel balls securely fastened to the tines which render it impossible for them to injure the roots, should be used.

EFFECT OF FREEZING.

Simple freezing of the beet would not cause any change in the sugar contents. The effect of freezing seems to be the driving of the sugar into the lower part of the beet, and if thawing be prevented there will be no loss. If beets are exposed to a heavy frost for a longer period that effect will be to cause considerabe damage. If the freezing has been light no damage would result, even if by a *gradual* change in the temperature the beets should slowly thaw up. Slightly frozen beets will only be unfavorably affected by a sudden change in temperature.

Thus it is explained that the upper layers of siloed beets suffer most by freezing and turn black as they thaw too quickly under the influence of sunshine and warm winds, while the lower layers are not at all affected.

SUGAR LOSS BY DRYING OUT.

A question of great importance to both the beet grower and the factory is, what changes will occur in the beet during the weeks that elapse between the time the beets are taken out of the ground till they reach the slicer in the factory? This question is not of so great and immediate interest to the beet grower, unless the factory should refuse to receive and hold the beets, but require the grower to either hold them until the factory is ready to work them up or in some way require the beet grower to share the loss resulting from drying out.

It is important for the grower to know how fast beets dry out, because if he sells them by the ton the drying out reduces his tonnage. It is, on the other hand, important for the manufacturer to know whether there is any loss of sugar, because, having bought the beets and paid for the sugar in them at the time of delivery, he wants to know whether the sugar will keep until he is ready for its extraction.

Dr. Maxwell gives the loss by drying out as from 16 to 26 per cent. for beets tied up in a sack and kept from the wind and sun for a period of seven days, and from 23 to 35 per cent. for beets under normal exposure to air and sun for the same length of time. He makes the average loss in the case of beets protected from the action of air and sun 20 per cent. in seventeen days.

Dr. Wiley, in his report on experiments in sugar beets in 1892, says: "The loss of moisture during transportation or failure of the farmers to send in their beets as soon as harvested may tend to reduce the amount of water present in the beet and to raise correspondingly the sugar therein." In speaking of beets received from California he said: "The beets were long in transit and must have lost a considerable quantity of water. They were somewhat wilted and shriveled in appearance when received. Such beets, of course, would indicate a higher percentage of sugar than they would really contain in a fresh state, and the same remark may be applied to the beets shipped by mail any distance, or to beets which have been exposed any considerable time to to the air after harvesting before the determination of sugar."

Experiments at Fort Collins, Col., according to Bulletin No. 46, agreed in showing a loss of rather more than 38 per cent. in seventeen days, and also quite a uniformity in the rate of loss, with the greatest irregularities during the first days of the experiments. The maximum of loss for any single twenty-four hours was 5.4 per cent. of the weight of the beets at the beginning of the twenty-four hours. It fell trom this to about 2 per cent. for each twenty-four hours, where it remained. Dr.

Maxwell made the average loss equal to 20 per cent. The Fort Collins Experiment Station made it somewhat higher. Still there appeared a substantial agreement between the experiments.

The farmer will appreciate these figures more fully, perhaps, when expressed in other terms. They mean this to him: If he has a crop of twenty tons to the acre and delays marketing it for twenty-four hours he has lost one ton, or one twentieth of the crop, and if he delays a week he will lose one-fifth of his crop by weight. The percentage of sugar will be higher, but the tonnage less by the amount of evaporation.

COST OF GROWING BEETS AND PROFIT IN GROWING THEM.

It will be readily undeastood 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, the skill of the grower and the choice of seed are factors of prime importance. Seed suited for one locality would not suit for another. Then the cost will depend on the price of labor, rent of land, cost of fertilizer, the acreage planted and the kind implements used. Those who have grown beets, using only ordinary farm implements for seeding, cultivation and harvesting, state that the cost per acre is about $20.00 to $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.

The farmer who wants to grow beets must remember that a first season means for him a season of education. Beet growing is something different from other crops. It needs special tools, special care and special attention. Where these would be lacking results would naturally be lacking, too.

The writer had frequent opportunity to notice a fixed idea with some farmers that sugar beet raising involved larger risks than other crops, or that the margin of profit was small.

The fact is that there is no crop which on a large scale will pay as well. A frequent source of failure is that farmers new in the business will contract to furnish a larger amount of acreage than they can handle. I have known cases where farmers contracted to furnish three and four times the acreage they could possibly handle, the inevitable result being failure and disappointment. I most strenuously advise every farmer who starts into beet culture to go it slow at first. No one acting judiciously would venture into a new business in which experience and special knowledge must be acquired so deeply as to expose himself to extra risks. Frequently the agriculturist or field agent of the factory is to be blamed. He ought to make sure that the contracting farmer is fully able to take care of the contracted acreage, otherwise both farmer and factory will be sufferers.

There are three good, valid reasons why farmers who have started right in beet raising continue to raise them and are so eager in competing for factory contracts that factories are often offered twice the amount of beets they are able to handle. These reasons are:

1. It is the surest crop the farmer can raise.
2. It is a cash crop, with the price practically fixed.
3. There is more money in it than in any other crop.

I give a few instances of what profits were made by beet farmers in various States, as reported in the public press. An Omaha paper reported the experience of H. C. Graves & Sons as follows:

> "They planted over forty acres of sugar beets at Council Bluffs, which were shipped by rail to the Oxnard factory at Norfolk, Neb., 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 profit would have been $2,495.99, or at the rate of $57.73 per acre.

In an interview in the *Caro Courier* John Callan gives his experience and the results of his 1899 campaign as follows:

> "I raised five acres of sugar beets for the Caro refinery. The land used was a clay loam on top about ten inches deep, underlaid by red clay. I kept account of the cost of raising this crop and give the following items:

Plowing	$ 7 50
Dragging and fitting	4 50
Drilling	2 50
Thinning, $5.00 per acre	25 00
Cultivating four times	3 00
Pulling and topping, $8.00 per acre	40 00
Drawing twenty-eight loads	28 00
Seed, ninety pounds	13 50
Total cost	$124 00
Delivered at refinery 67 tons 200 pounds of beets, for which I received $4.62 per ton	310 00
Credit balance	$180 00

Any number of corroborating testimonials may be obtained from farmers in beet-raising localities.

BEET DISEASES AND BEET PESTS.

Funguous diseases happily have as yet not made their appearance in most of our beet growing sections. Beet scale has been found here and there, but only to a limited extent. It attacks the roots or beet proper, giving them a rough, "scabby" appearance. It is considered identical with potato scab, although the diseased patches are of larger size. Authorities on beet diseases advise not to plant beets upon ground on which potatoes have recently been raised, and which might contain the germs of the disease. Root rot has been found where beets have been sown on soil heavily and freshly manured with a manure rich in nitrogen.

Crown gall is another disease which has shown itself in a few localities, and makes itself known by the appearance of knotty protuberances on the crown of the root.

The "leaf spot" disease, or leaf blight," is probably the most serious of beet diseases. It impairs the crop by destruction of the foliage, thereby preventing the elaboration of sugar in the beet. It shows itself by the formation of small yellowish-white discolored spots, which soon cover the entire surface of the leaf, and generally attacks the older leaves first. By spraying with fungicides, such as "Bordeaux Mixture," the disease may be checked and the younger leaves prevented from taking the disease. The disease is said to be more destructive on land upon which beets have been raised two years or more in succession. Dry rot has appeared in some sections, even where beets were planted on ground never before used for any crop liable to leave behind germs that would cause it; hence the contention that it is sometimes introduced by beet seed. Where this is the case steeping the seed in one-half per. cent. watery solution of carbolic acid is recommended as the simplest, cheapest and safest method of treating the seed. If the disease emanates from fungi or bacteria present in the soil disinfection should be aided by liming and suitable treatment of the soil. The germinating power is not impaired by this remedy.

None of the mentioned diseases have been very destructive as yet, and the consensus of opinion of most of our Entimologists is that they will not prove seriously harmful. I would advise, however, the farmer as soon as he discovers any disease in his beet fields, and likewise when they are attacked by any of the insect enemies of the beets, such as the "flea beetle," web worms, gophers, etc., to at once apply to the factory agriculturist or the Experiment Station for remedial advice.

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 manufacture 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.

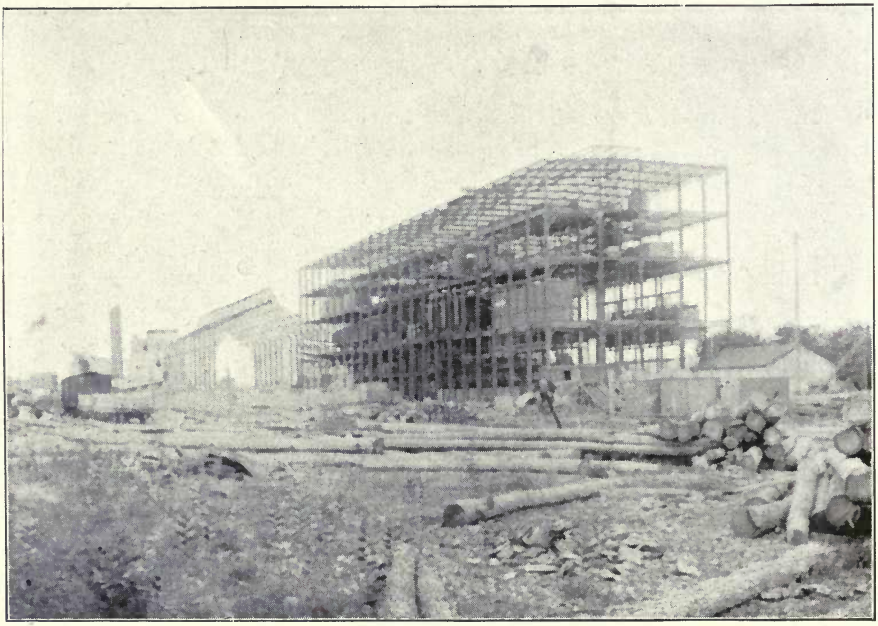
FACTORY REQUIREMENTS.

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 highest possible 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 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.



BAY CITY SUGAR CO.'S FACTORY, BAY CITY, MICH., IN COURSE OF CONSTRUCTION.

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 beet fields 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 shrinkage 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 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 produced, 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 3,600 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 crystallizable 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. Fifteen of the 17.65 parts, or approximately 85 per cent. is sugar. Prof. 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 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 crystallizing. 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 itself, also carry much foreign matter."

DIFFERENT METHODS OF OBTAINING BEET SUPPLY.

The sugar factories now existing and under construction secure their necessary beet supply in different ways:

1. By making contracts with farmers, relying altogether for the supply on the farmers, the sugar company not participating in any agricultural work whatever by way of beet raising.
2. By partly relying for the beet supply on the farmers and partly on the raising of the beets, with the assistance of hired help, on lands owned by the sugar company or leased from neighboring landowners. The bulk of the supply might be raised either by the sugar company or the farmers.
3. Where a company or its members own a very large tract of land, by renting the same in sections to smaller farmers for beet raising, eventually selling the sections to them, and thus colonizing the entire estate.

The main argument in favor of variation No. 1 is the well-known principle of the division of labor, to which is added the division of risk.

The farmers on one side produce and furnish the necessary raw material and utilize the waste products which result in beet raising as well as in the factory, while the factory on the other side takes the risk of the large investment (sometimes millions of dollars) necessary for establishing and operating a factory and attends to the manufacture and sale of the marketable goods. Thus the farmer escapes all risk resulting in the manufacture by market fluctuations, etc., while the manufacturer, on the other hand, avoids in a large measure the chances and risks which attend agriculture, these latter falling to the farmers' share.

The advantages and disadvantages of raising part or the main portion of the necessary supply on land owned or leased by the sugar company and under the direct management of the same are plainly apparent after what has just been said. The manufacturing company secures for itself more or less independence of the farmers, but takes upon itself the additional risk of the larger investment of capital required to carry on the agricultural part of the business as well as the risks with which agriculture in general has to contend, such as the influence of the weather, securing of field labor and other emergencies.

The variation mentioned sub. 3 has many points in its favor, and in a measure combines the advantages of the other variations. As a rule the value of the land will have increased to such an extent after one or two active seasons of the sugar factory that the company, if it feels thus disposed, can sell out its holdings to the beet farmers. Of course when doing so the sugar company will secure for itself a guarantee for a stated supply of beets to be grown by the purchaser of its former lands for a certain number of years. In many cases the farmer will pay for the land purchase by raising an agreed upon acreage for the factory year after year, the value of the delivered beets being credited to him on account of the purchase sum. In this manner both farmer and factory are benefited. The farmer will become owner of valuable and well-paying land in course of time without requiring any original cash investment on his part, while the owners of the land and of the factory erected thereon must derive big profits through the increase in value of rentals and selling prices of lands, aside from the profits resulting from the operation of the factory, *i. e.*, the sugar and by-products manufactured or obtained.

In this connection a few words in regard to

CO-OPERATIVE BEET SUGAR FACTORIES.

Co-operative beet sugar factories flourish in many beet raising sections of Europe, particularly in Germany. These factories are run as stock companies, the majority of the stockholders being farmers, every farmer being obliged to cultivate for each share held by him a certain area of land with beets, and to deliver these to the factory after they are harvested. Settlement is made on the basis of a price fixed by the Board of Directors. Capitalists, who are not farmers and do not possess any farm lands, are interested in some of these factories, but they are also obliged to furnish beets, and must, therefore, make contracts with farmers in order to supply the factory with their share of beets.

It is claimed that these factories give better financial results than those run by private individuals, for the reason that: Firstly, the necessary beet supply is always assured, and, secondly, that the farmers interested in the factory as stockholders enjoy all the advantages resulting from the large quantities of feeding and fertilizing materials obtained in the by-products of the factory.

Whether co-operative farmers' sugar factories can be successfully established in this country is hardly to be doubted. Yet efforts made in various States in this direction have so far fallen short of success. Of course there stand many difficulties in the way of establishing such factories here at the present time which do not exist on the other side. The conservatism of our farmers, the newness of the enterprise, etc., are, however, obstacles which in time may be overcome. Probably the main difficulty is that we have not as yet in the suitable locations a sufficient number of farmers who can afford to go into an enterprise of this kind. Some of the German co-operative companies number from 150 to 200 farmers among their stockholders, and there are no doubt locations in this country where a similar number of farmers would be able to bring up the necessary capital for establishing a factory.

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 running stream 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.

Where there are no other means of supply artesian wells are resorted to. An analysis of the water should be made in order to determine its purity. There may be certain salts contained which would affect the manufacturing process unfavorably. For instance, sulphate of magnesia and chloride of magnesia are molassic, or, in other words, are not precipitable, and consequently they will be found in molasses. One part of salt or ashes prevents three and one-half parts of sugar from crystallization. It is the same with sulphate of soda. Carbonate of lime is practically harmless alone, but will combine with silica and form a hard deposit on boiler tubes and multiple effect tubes. Of the sulphate of lime part will combine with carbonate of lime and silica and part will go in molasses.

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. of Sc. of the United States Department 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 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 carbon ates 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:

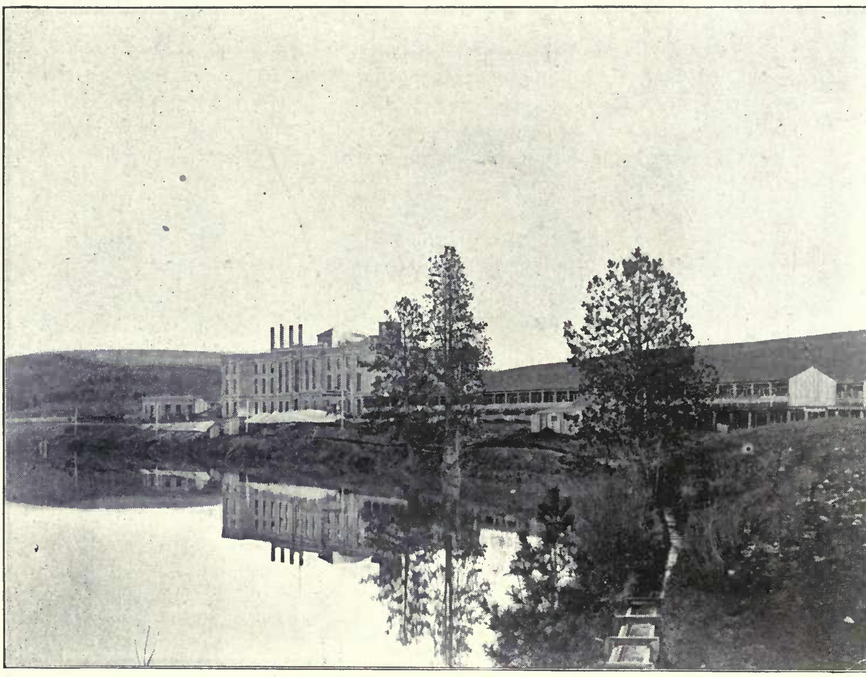
> "The following salts are positive molasses makers, that is, salts which promote the formation of molasses: Carbonate acetate, butyrate and citrate of potassium.
>
> "The following have no influence on the formation of molasses and are classified as indifferent: Sulphate, nitrate and chloride of potassium, carbonate and chloride of sodium, calcium hydrate, 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 calcium and the aspartate of potassium."

Drainage facilities are another very important requirement. There are several instances on record where factory owners have been put to no end of trouble and considerable expense by not giving this point sufficient thought when selecting the site.

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 limestone and for producing corbonic 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 seventy-five tons of coal and seven and one-half to ten tons of coke every twenty-four 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



FACTORY OF THE WASHINGTON STATE BEET SUGAR COMPANY, WAVERLY, WASH.

be seventy-two-hour coke, practically free from moisture and should contain about 92 per cent. of carbon and not more than three-quarters 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, and last, but not least, the quality of the coal itself. 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 Indigene*, the leading paper of the industry in France, in its issue of March 16, 1897, 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 seventy kilos with our regular quality of French coal per ton of beets. The factory at Ouval, Bohemia, shows a figure in fuel below seventy kilos, and in locations where coal is cheap 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.

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
	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct	per ct
Moisture	4.10	5.10	7.25	4 15	4.17	6.25	5.16	.52	1.21
Sand, Clay and Insoluble Matter	4.50	5.15	4.90	2.15	3.07	3.17	2.25	2.85	.55
Organic Matter	1.20	1.17	1.37	1.05	.97	1.12	.86	.30	.41
Soluble Silica	2.10	1.75	3.30	1.05	.98	.64	.56	.06	.20
Oxides of Iron and Alumina ($Fe_2O_3Al._2O_3$)	.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
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
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.000	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 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 "scaffolding" in the kiln.

"Excessive moisture, 5 per cent. or more, in the stone reduces the temperature of a kiln when charging, involving an imperfect combustion and the production of carbonic oxide (CO); further, such stones break into small pieces under the influence of the heat. A small proportion of water, approximately 1 per cent., 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."

Here, as also in buying other supplies, the maxim that the best is the cheapest will be found to be true. The few cents added to the cost will be amply repaid by the results.

LABOR.

The question of securing the necessary labor for field and factory is an important one. 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.

From the following schedule an idea as to the labor required in a well-managed factory may be obtained:

AVERAGE LABOR REQUIRED FOR A 500 TONS CAPACITY FACTORY.

STATION.	Number of men.		STATION.	Number of Men.	
	Day.	Night.		Day.	Night.
Superintendent	1	.....	Lime Kiln	3	3
Chief Agriculturist	1	......	Lime Room	1	1
Assistant Agriculturist	2	.....	Lime Slackers	2	2
Foreman	1	1	First Carbonation	1	1
Chief Engineer	1	......	Carbonation Helper	1	1
Assistant Engineer	.....	1	Second Carbonation	1	1
Engine Driver	1	1	Filter Press Man	1	1
Oiler	1	1	Filter Press Assistant	4	4
Machinist	1	......	Sulphitation	1	1
Millwright	1	1	Mechanical Filters	1	1
Blacksmith	1	......	" " Assistant	3	3
Chief Chemist	1	......	Wash Machine	1	1
Assistant Chemist	1	1	Quadruple Effect	1	1
Help in Laboratory	3	......	Sugar Boiler	1	1
Tare Master	1	......	" Helper	1	1
Assistants in Tare Room	3	......	Crystallizers	1	1
Ash Wheeler	1	1	Mixers	1	1
Sweeper	1	1	Centrifugals	1	1
Weighmaster	1	......	" Assistants	5	5
Weighmaster's Assistant	1	......	Sugar Melters	1	1
Sample Taker	2	......	Granulator Box	2	2
Timekeeper	1	1	Sugar carriers to Melter	2	2
Storekeeper	1	1	Packing Room	6	6
Swimmers in Sheds	2 to 5	2 to 5	Sugar Inspector	1	......
Stone Dipper	1	1	Head Fireman	1	1
Wash House	3	3	" Assistants	3	3
Slicers	2	2	Water Tender	1	......
Knife Grinder	1	1	Yardmaster	1	......
Diffuser	1	1	Yard Laborers	8	......
DiffuserHelper	1	1	Watchman	1	1
Juice Boy	1	1	Cloth Cutter	1	......
Pulp Pit	3	3	Steamfitter	1	......
Pulp House	1	1			

This schedule does not include the office help, nor the labor for unloading beets, lime rock, coke and coal, generally done under contract. Many men employed by the factory during its manufacturing campaign are not needed for factory work during the beet growing season and can be secured for field work. There has been displayed a tendency by the managers of some of our factories to cut down labor. This is trying to economize in the wrong place. The absence of a man from his post for only a few minutes to attend to work for which another man should have been employed might cause a loss of many thousands of dollars, and I know of more than one factory where the campaign result suffered considerably through this mistaken policy.

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.

From the foregoing it follows that, other things being equal, it is best to locate where water (river or lake) and railroad facilities are available, and near some center of population, although the latter is not absolutely necessary.

In this connection it may be mentioned that the sidetracks necessary for the handling of the in and outgoing freight of the factory are generally laid by the interested railroad companies.

MARKET FACILITIES.

A ready market in close proximity to the factory is perhaps not one of the least important conditions of 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.

CAPITAL NECESSARY FOR ESTABLISHING VARIOUS SIZED SUGAR PLANTS.

The cost of a sugar plant and the total investment necessary to establish and operate such a plant depends on a number of conditions. 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 preceding pages I 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 plant, kind of equipment, 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 words, 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 larger the size the smaller the cost of a beet sugar factory. The size of a projected sugar factory must be made dependent, however, in the first place on the amount of beet acreage securable. The question of beet supply has already been fully discussed.

It is not advisable to build a plant with a smaller daily capacity than 300 to 350 tons. If acreage and capital can be secured for a larger plant so much the better, for not only is the cost of construction less in the larger plant, but there is also a proportionate reduction in the operating expenses. Let the prospective investor understand thoroughly that any attempt of putting up a cheap plant and making sugar in a small way would be bound to turn out a failure. It would be rank foolishness to go into 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.

There is hardly a line of manufacture where the apparatus has undergone in the last twenty years such considerable changes as in the sugar manufacture. It is true that many parts of the equipment are still the same, but the diffusion battery, multiple effect, the pans and centrifugals, representing the most important parts of the machinery, and especially the apparatus for working up the after products, have undergone great changes within the time mentioned.

BEWARE OF OLD BUILDINGS AND OLD MACHINERY.

The opinion seems to obtain with many people 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 simply that much money thrown away. No old and discarded apparatus, no matter how useful in former years, would serve the purpose. Not one of the various enterprises 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. Moreover, alterations are generally dearer than the cost of erecting new buildings, not to speak of the advantages of new buildings over old ones.

But above all, in order to make a success of a beet sugar factory it must be built and equipped on modern principles, fitted out with the best machinery that can be bought for money; in other words, the most perfect, labor saving and least expensive to operate, machinery that will extract the largest amount of sugar of the best quality at the least cost.

HOW TO INTEREST CAPITAL.

There are many locations in many of our States where all the necessary conditions for the successful operating of a sugar factory exist, but where local capital either is lacking altogether or not sufficiently strong to carry through a factory project.

A community wishing to secure outside capital for the erection of a beet sugar factory must demonstrate by undisputable proofs that it can offer all the advantages required for the successful operation of a factory, but first and foremost, that it is able to furnish the nesessary beet supply. With the convincing results of the now existing factories before their eyes capitalists are much more easily interested in beet sugar enterprises than formerly, but they will turn down any proposition that does not guarantee the beet supply for the projected factory. The prime question, therefore, is to secure this beet supply. The best way to accomplish this is to get a number of prominent business men and farmers to form a development company. Let them subscribe a certain amount, say $1,000 to $2,000, to defray expenses of a canvass among the farmers to secure contracts, say for a year or two years, running from the time the factory is to be started. This acreage should be secured as near as possible to the point where it is intended to locate the factory. If a community can show that it has all the required advantages it will find no difficulty in securing the necessary capital.

Very frequently in localities where favorable conditions exist local organizations are importuned by promoters, offering to construct a factory on condition that a stipulated sum should be paid to them as a bonus, either in cash or in lands or in beets to be furnished.

Such propositions should be peremptorily declined. In most cases they are schemes by that genus promoter whose sole object is to line his pocket with bonuses, make money out of land sales and watered stocks and bonds, while he cares nothing about the success of the factory. Enterprises based on such schemes are a menace to the industry and apt to turn out a failure. We have had such regretable failures, and it is to be hoped that they will prove a lesson to the investor. Moreover, a beet sugar factory in any location where favorable conditions obtain can be financed without the dangerous and questionable stimulus of a bonus.

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 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, 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 aforementioned 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, beet sheds, sugar storage house and office building. Sometimes one or the other of these annexes is included in the main building.

The following represents a good plan of the internal arrangement of an up-to-date sugar plant:

GROUND FLOOR.

Washer.
Beet elevator.
Pulp pit under diffusion battery.
Engines and dynamos.
Pumps.
Centrifugals.
Sugar melter.
Sugar elevator.
Machine shop.
Office.

SECOND FLOOR.

Beet elevator.
Diffusion battery.
Carbonation tanks.
Quadruple effect (evaporators).
White sugar mixer.
Granulator.
Sugar elevator.
Dust room.
Laboratories.

THIRD FLOOR.	FOURTH FLOOR.	FIFTH FLOOR.
Crystallizers.	Beet elevator.	Sulphutation tanks.
Pulp presses.	Automatic scale.	Condensers.
	Slicer.	
	Filter presses.	
	Vacuum pans.	
	Mechanical filters	

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

CONSTRUCTION OF BUILDINGS.

A beet sugar factory, considering the immense amount of heavy machinery required in its various departments, must be built solidly from bottom to top. Where the factory is located on or near a water front wood piling for foundations must ordinarily be resorted to. It is undoubtedly the most satisfactory and reliable method of securing in the ground the resistance necessary to hold up to their proper levels the buildings carrying such heavy weights. Concrete blocks are placed around the heads of the piling; they are less bulky, and, as a rule, cheaper, than brickwork for the same purpose. Stone masonry on a good bed may sometimes furnish satisfactory and cheap foundations for walls and piers, but cement concreting or brick will generally be found the cheaper method.

While there is not so much danger to sugar factories from fire as is usually supposed, in the newer plants steel fire-proof construction is generally adopted. For the walls stone or brick is used, while the floors throughout are made of concrete.

A plan now frequently adopted by builders of beet sugar plants is to construct the buildings large enough on the start to enable doubling or increasing the capacity of the plant at a given moment. This for the reason that the first campaign is generally one of education both for the farmer and the factory owner. Frequently farmers are slow the first season in supplying acreage, and, owing to the inexperience of the growers, the result of the contracted acreage does not come up to expectations, but after one or two seasons, when the grower has mastered the intricacies of beet culture and experienced its benefits, he will come readily to the front with a larger acreage.

PROCESS OF MANUFACTURING SUGAR.

The beets, freed from tops and adhering dirt, are delivered at the factory in wagons or cars. They are then weighed and sampled. For the purpose of ascertaining the actual tare an average sample of fifty pounds is taken from each load. This sample is thoroughly cleansed and examined to see if the beets are properly topped, then weighed again, the loss determining the tare. After the weighing and sampling the beets are unloaded into the storage sheds.

Beet Storage Sheds must be arranged with separate approaches or roadways for cars and wagons, and should be roofed in such a manner that the unloading of cars and wagons may be done under cover. The sheds have V-shaped bottoms, at the apex of which are covered conduits or flumes extending the entire length of the sheds and thence to the wash house. The flumes, which may be constructed either of iron or cement, have a movable covering. When ready to start operations, beginning at one end of the beet shed, part of the covering is removed and the beets allowed to fall into a swift current of water, which floats them into the factory. The flumes conveying the beets to the factory should be provided with a sand and stone catcher, thus arranged that the stone and pebbles accumulating can be taken out without stopping the flow of beets.

WASHING AND SLICING THE BEETS.

The beets on arriving at the wash house are carried by a revolving wheel, the so-called beet wheel, to the washer.

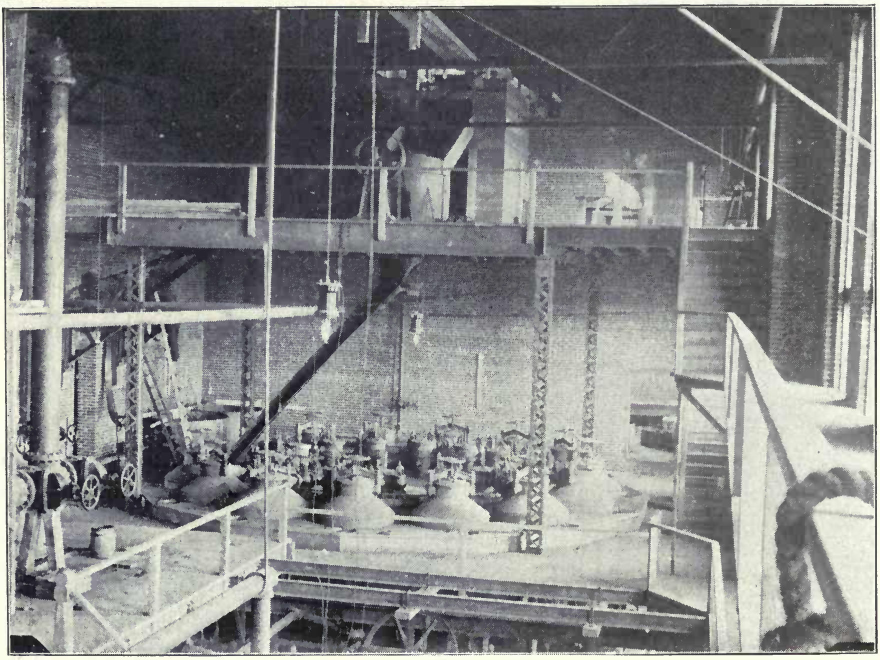
Washer: This apparatus consists of a tank kept constantly full of fresh water, where the beets are subjected to a thorough washing by means of propeller arms attached to a shaft running through the center of the tank, which convey them from one end of the tank to the other, keeping them constantly agitated, in order that any adhering soil, particles of leaves, together with any sand or pebbles, may be completely removed. When thoroughly cleansed the beets are ejected from the washer by means of an automatic device and fall into a vertical iron bucket elevator, which carries them to the automatic weighing machine and slicer on an upper floor.

Automatic Beet Scale: The beet scale is an automatic machine which weighs 700 or 1,000 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 the same. No mistakes are made in calculation, and it is absolutely impossible for any of the workingmen 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 into such shape to avoid their laying too closely together 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 V-shaped knives, cutting a large number of slices off the beets at every revolution.

Many improvements have of late been devised with the object in view to obtain slices of the greatest possible regularity in size, which is all important for the successful working of a diffusion battery. To obtain this end the knives must be evenly attached in the frames. Among the newer inventions may be mentioned the double-knife Bergreen slicer, with beveled instead of flat knives to produce slices offering the greatest facilities for osmotic action, while preventing the sticking together of the slices.

The new Putsch blade holder is held by the part holding the blade protector on the plate of the slicer disk. Thus the box holding the



WASHINGTON STATE SUGAR COMPANY,
WAVERLY, WASH.

Showing Slicer, Diffusion Battery and Revolving Chute delivering sliced beets from the Slicer into the cells of the Battery.

knives may be placed in position from the top. The elongated openings of the blade enable rapid working of the regulating screws and the obtaining of cossettes of desired size in short order.

The Manguin slicer, a French invention, is novel in shape and working. The drum working on a horizontal shaft has eight plate holders, with six knives each. By an arrangement inside the drum the beets are carried one by one past the knives, which slice rapidly parallel to each other, producing slices of great regularity. It is claimed that a larger amount of beets can be sliced by this slicer in a given time than by any of the existing slicers.

DIFFUSION BATTERY.

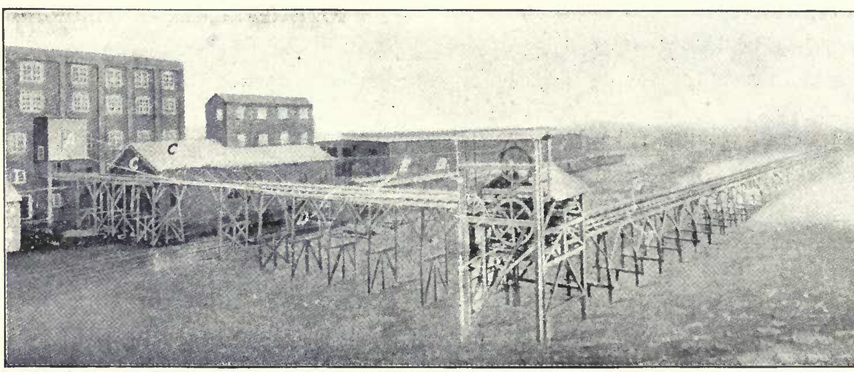
By means of a revolving chute the fresh beet slices (technically called cossettes) are conveyed into the large cylindrical closed tanks or cells of the diffusion battery on the floor below. These cells (each holding about two to two and a half tons) are arranged either in a circle or in straight rows, 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 so-called "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 (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 cell membrane, 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 in 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 to 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 centrifugal 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. At present, however, what is known as the diffusion process is universally used. It 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 cell membranes of the sliced beets allows the sugar in the cell to diffuse with the water on the outside until it 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.

THE PROCESS OF DIFFUSION.

The operation is proceeded with as follows: First one cell is filled with 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 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 meantime fresh water has again been forced into the first cell and passes through the entire number of filled cells in regular order. 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, and cell No. I now becomes the last in the series. The second cell is next to be exhausted and recharged in its turn, and thus every following cell continuously.

The exhausted cossettes or pulp fall into a pulp basin, usually constructed of cement, underneath the diffusion battery, and are carried through a helical press or screw conveyor, by which a portion of the water they contain is removed, to the outside of the building, where the beet pulp conveyor takes care of it. The water extracted by the press goes to waste.

A new method has lately been devised by Dr. Pfeiffer and introduced in several German factories. By this method the diffusion cells are discharged by air pressure. Among the advantages claimed are quick discharge of the cells without hand labor, working at higher temperature, thereby producing good and pure juices and leaving the pulp warm, enabling more rapid drying and pressing out of the pulp, hence a saving of fuel.

BEET PULP CONVEYOR.

This conveyor delivers the pulp to the cars or wagons or takes it to a place of storage.

The cut on opposite page shows a Garland beet pulp conveyor as installed in many of our beet sugar plants. The illustration is reproduced from a photograph taken at the plant of the Bay City Sugar Company, Bay City Mich.

The pulp is discharged from the pulp press into the pulp house A, an extension projecting out from the main building. In this building is located the end of the cross line conveyor and the necessary wire-rope driving machinery. In the tower B is located the machinery which operates both conveyors. C is a steel power transmitting cable ⅝ in. in diameter, spliced endless, 540 feet long. This cable receives its power from an 8-ft. wheel in the building A passing out over the idlers J and J and around the 8-ft. cable wheel K, which furnishes power to the bevel and spur gears to operate the entire driving machinery for the 250-ft. and 500-ft. lines of conveyor. The idlers J are arranged in vertical tension carriage, so the cable C may be tightened up at will or as may be required.

In the first section is seen the 1-in. steel cable, on which the clamps E are spaced at intervals of 37.6 in. To each of these clamps is secured by two bolts a maple flight 18½ in. long and 6 in. wide, which carries the pulp forward to the tower B, where it is discharged into the 500-ft. line of conveyor F G H and conveyed to the pond. This cable E is 1 in. diameter, patent steel, and is coupled with a patent coupling. The breaking strain of the cable is thirty-seven tons, or 74,000 pounds.

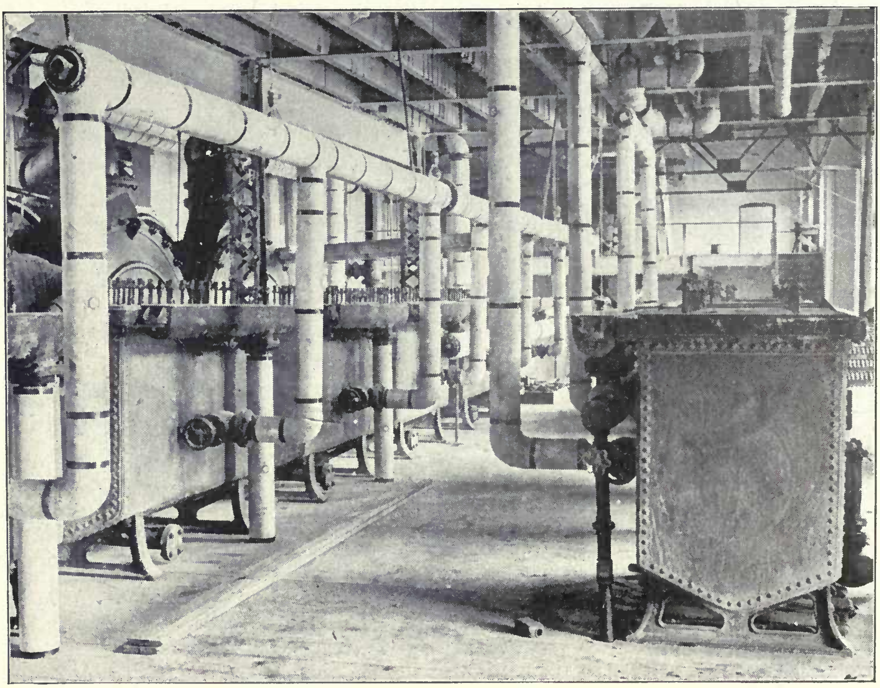
The object of the use of these large cables is that they afford a greater surface on which to grip the clamps.

In the 500-ft. line at F may be seen the conveying cable, which is 1⅓ in. diameter, patent steel, and spliced endless 1,021 feet 3 inches. The breakage strain of this cable is forty-seven tons, or 94,000 pounds. At G is shown one of the maple flights above described, which are spaced on this cable 37¾ in. centers throughout its entire length. At H is lacated one of the 6-ft. cable wheels for 1⅛ in. cable. This wheel is arranged in tension carriage so that all slack cable may be taken up at will. The tension carriage in the first conveyor is located in the power house A.

D E is what is termed a pull conveyor, because the power is applied at the discharge end.

CLARIFICATION OF THE JUICE.

The juice as it leaves the last cell of the diffusion battery is drawn into a measuring tank, where it is accurately measured and a record taken of time, number of cell and density. The juice is then anything but inviting in taste, smell or appearance, which is due to the salts and organic impurities which it contains. The reason that the juice contains these non-saccharine substances is that all salts, partly bound to vege-



WASHINGTON STATE SUGAR COMPANY, WAVERLY, WASH.
MECHANICAL FILTERS.

table acids, as they are found in solution in the juice, diffuse almost as easily as the sugar in solution. To rid the juice of these impurities it is first passed through colorizators or heaters and then to the carbonators. In the colorizators the juice is heated to a temperature of about 190° F. to cause coagulation of the albuminoids. The heating may be also accomplished by placing a steam coil in the carbonators.

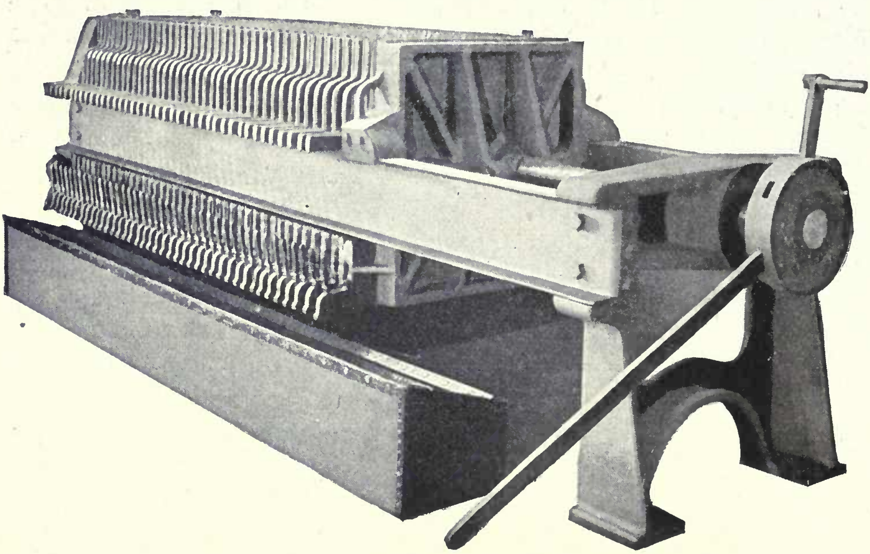
First carbonation. The juice now passes into the first carbonators, large closed rectangular or cylindrical tanks with valves and appliances for admitting juice, lime and carbonic acid gas. Slaked lime in the form of milk of lime is introduced in the heated juice for the purpose of having the lime unite 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, which is subsequently separated by filtration. The lime also combines with the sugar, forming a sucrate of lime. In order to separate the lime and sugar, carbonic acid gas is injected by means of a distributing arrangement placed at bottom of tanks. The gas bubbles through the lime 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. The juice drawn off from the first carbonators contains the precipitates and other mechanical impurities, and to rid the juice of them it is pressed through filter presses.

The lime and carbonic acid gas required for the operation are produced in specially constructed lime kilns.

Lime Kiln. Most of the newer lime kilns are of long oval shape, constructed of steel and brick, with a lining of fire brick. The kiln should rest on an open iron grating, and not directly upon the ground, to allow of satisfactory circulation of air. The kiln is kept full of a mixture of coke and limestone, the former of about the size of a walnut and the latter a little larger. This limestone and coke is introduced at the the top by an elevator. The air enters at the bottom, where also the burned lime is withdrawn, which goes to the lime-slacking tanks; the milk of lime, after being measured in a measuring tank, is forced by suitable pumps to the carbonation tanks before described. The gas is drawn from the top of the kiln by suitable mechanical devices and carried by pipes after passing through the carbonic acid gas washer. The amount of coke used depends mainly on the quality of the limestone, as does also the amount of carbonic acid gas obtained. In a well-constructed kiln, with good limestone, the average amount of coke used should not exceed eight pounds per 100 pounds of limestone.

The object in burning the limestone in the factory instead of buying the prepared lime is to make sure of fresh burnt lime, and, furthermore, to secure the carbonic acid gas needed for the carbonation process, as well as the slacked lime as just explained.

First Filtration. The juice is forced by means of pumps at a proper pressure per square inch through presses consisting of a series of frames and screens. 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 filter cloths any juice left. The press is then opened and the lime cake removed and carried by means of a conveyor outside of the building. The aforementioned trough serves also as a measuring tank for the wash water of the lime cakes. There are many filter presses in the market of widely varying patterns, for all of which points of special advantage are claimed. Among those which are said to have given the best satisfaction are the "Kroog," "Beeg," Selwig & Lange, and the filter presses built in this country on the Dyer pattern by Wm. R. Perrin & Co. The cut below illustrates one of the latter.

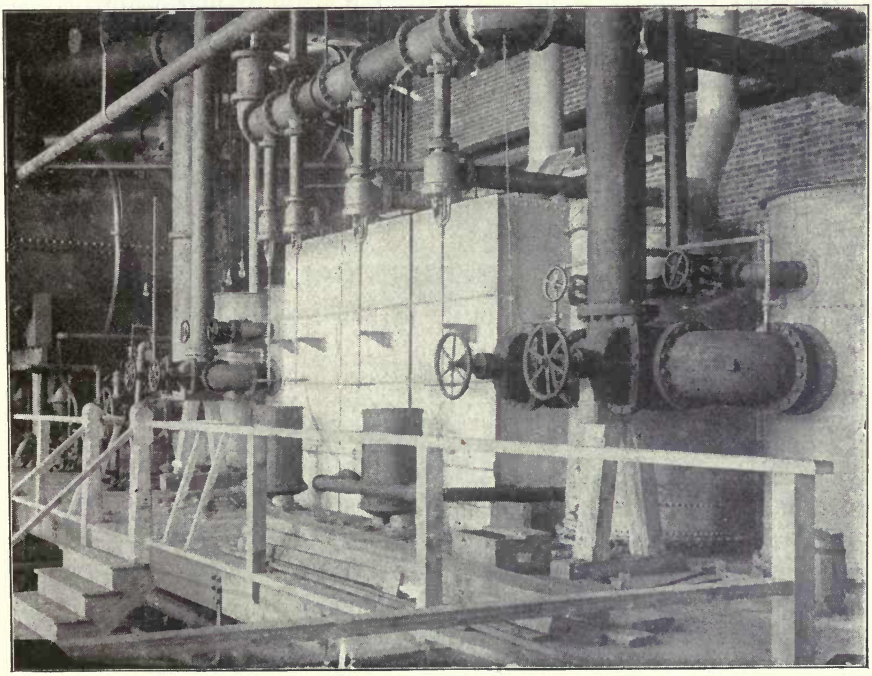


Although most of the impurities originally contained in the raw juice have been removed by the two processes just described, the purified juice is not as yet fit for the evaporating process, as they still contain a considerable amount of lime left by the first carbonation and some impurities, which are apt to pass into the juice with the wash water. It is, therefore, necessary to subject the juice to a second carbonation, and after this possibly to a third.

Second Carbonation. The juice and the wash water from the filter presses is submitted in a second set of carbonators 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 a test made by a standard acid with the aid of an indicator. 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. This second filtration has the same object as the first and is conducted in the same manner.

CONTINUOUS CARBONATION.

Lately quite a noticeable improvement has been made in the process of carbonating juice. For a number of years sugar manufacturers and chemists have been studying the question of continuous carbonatation. The problem was solved by the Societété Anonyme de Constructions Mécaniques, de St. Quentin, France, who constructed a continuous carbonatation which answered the requirements sought for a long time.



The above cut shows the apparatus used in the working of this process as installed by E. Salich & Co. in the Washington State Sugar plant at Waverly, where it has been in successful operation for two campaigns.

The construction of this apparatus is very simple, and consists either of two tanks communicating at the bottom or a single tank having a partition in the center, answering the same purpose as two tanks. The limed juice passes through heaters, where it is brought to the required temperature, into the first tank when two tanks are employed, or into the first compartment of a double tank.

On the second tank or the second compartment of the double tank a juice outlet is provided for. This outlet has the shape of an open kettle, and the flow of the juice can be watched constantly. The distribution of the carbonic acid gas is placed at the bottom of each tank, or each compartment, and has a separate inlet valve.

All that the man working around the carbonatation has to do is to regulate the inlet of the juice and the inlet of the carbonic acid gas to bring the juice to the right point of carbonatation. When the valves are fixed correctly and the factory runs smoothly, furnishing without interruption the necessary quantity of juice to the carbonatation, and if the lime kiln is so operated that there is no variation in the richness of the gas, the valves remain in the same position not only for hours, but for days, without any change.

Should the arrival of the juice not be very regular or fluctuation occur in the carbonic acid gas, all that is necessary is to open or close more or less either the inlet of juice or inlet of gas, or both of them.

As there is but very little work to do around this carbonatation, one man can easily attend to both first and second carbonatations. A further advantage is found in the easy cleaning of the apparatus, a saving in limestone and carbonic acid gas, and also a saving of space for the plant.

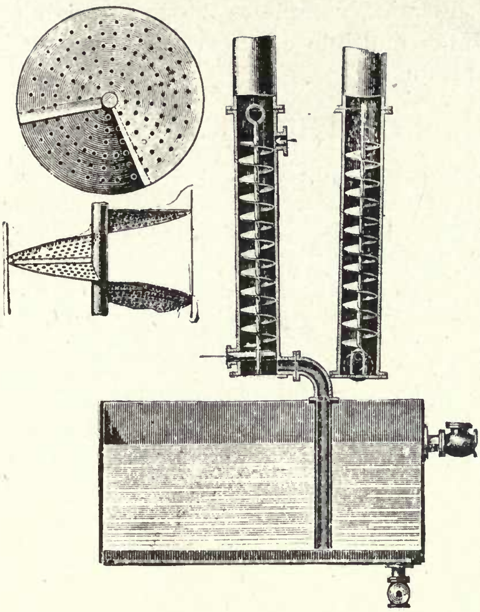
SULPHURING AND MECHANICAL FILTRATION.

The clear strained juice from the carbonators, which is at this stage of light amber color and almost pure, is forced by pumps to the sulphuring tanks or so-called "sulphiters," which are of the same general construction as the carbonators above described. By means of an air compressor sulphurous acid gas, obtained by burning sulphur in a furnace or gas generator, is forced into these tanks.

The gas generator has two compartments, one being used at a time, so as to allow of cleaning without interrupting the process. Air is pumped into one end by an air pump over the burning sulphur, and the sulphuric acid gas produced goes out at the other end through pipes to the sulphuring tanks.

The sulphurous acid acting on the juice decolorizes the latter, and also precipitates the remainder of the lime. The sulphuring is controlled by making tests of the alkalinity and by watching the color of the juice, which at the end of the operation closely resembles that of ordinary water.

An innovation has lately been introduced in some German factories which it is claimed combines a number of advantages, such as uniform saturation, uniform alkalinity of the juice, easy filtration, a saving in material and labor, while accomplishing the result much more quickly. As will be seen from the drawing, the sulphuring, instead of being done in a number of tanks, takes place in a single apparatus, consisting of a



horizontal cylinder provided with a helical worm. The juice is forced through the opening at the top, and in its downward course passes through the perforations in the worm in the form of spray, readily absorbing the counter current of sulphuric acid gas which is forced in the cylinder through the opening at the bottom, as the juice in the form of spray offers a larger surface for the action of the gas.

After the sulphuring process the juice undergoes another filtering in mechanical filters. These filters consist of iron boxes supplied with bags on the inside. The manner in which these filters work is just the reverse of pouring a liquid in a bag and allowing it to filter through, for the juice filters from the outside of the bag to the inside and then flows over and out of the top of the filter. The bags are stretched over copper frames to prevent them from collapsing during the operation.

A mechanical filter, patented by Hans Reisert, Cologne, has lately been put on the market, which it is claimed combines cheapness of the filtering medium, which is gravel, with great saving of time and of working expenses. The apparatus consists of a cylindrical or prismatic tank with two partitions for perforated metal plates and wire netting fastened horizontally at a given distance from each other. The space between them is filled partly with fine gravel, through which the juice is filtered. The washing out of the filtering material is accomplished by introducing compressed air through pipes with a number of small openings in them under the surface of the filtering material, causing a violent agitation of same, partly through the upward movement of the air and partly through the back flow of water, and thereby separating the impurities from the filtering material.

Similar to the just described apparatus is the Reinicke sand filter, consisting of several circular shelves arranged funnel shaped either horizontal or inclined. The juice is made to circulate through the sand from top to bottom, leaving behind on each shelf some of its impurities. The sand is cleaned in a special funnel, into which it is carried together with the impurities, by means of a jet of water, the sand settling while the impurities are carried off with the water.

The process of mechanical filtration completes the purification of the juice, which is then passed to the multiple effect evaporating apparatus for the purpose of concentration.

CONCENTRATION OF THE JUICE.

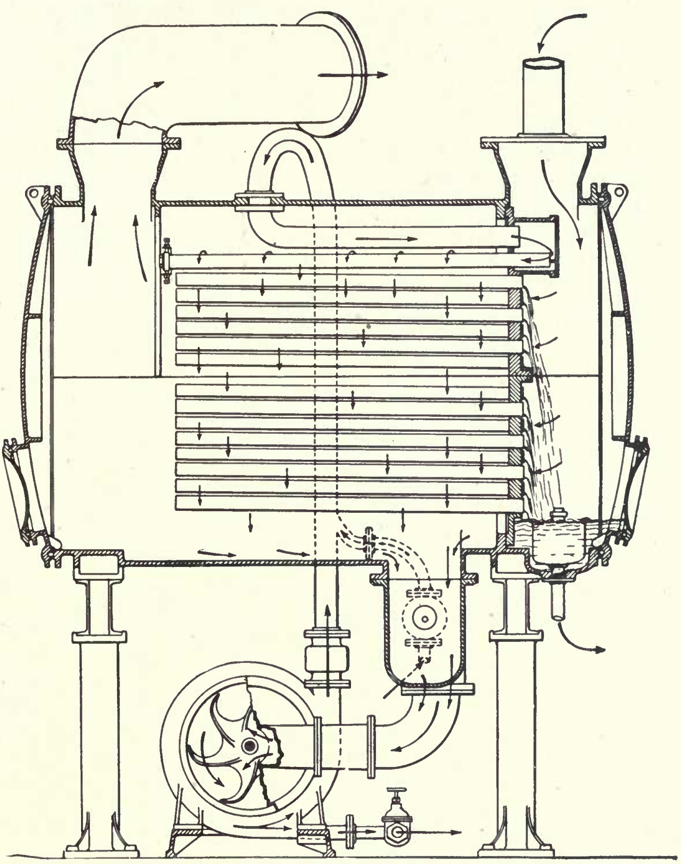
The concentration of the juice takes place in an evaporating apparatus or *multiple effect,* consisting of three, four or more bodies, called, according to the number of bodies, double, triple, quadruple, etc., effects. The design of the multiple effect is to use the latent heat of the exhaust steam from the various engines of the sugar house and to evaporate the juice at a low temperature. There are a great many types of evaporators, which may be divided according to their construction into two distinct classes, viz., upright and horizontal evaporators, most all of which work well when operated skillfully and where the juice reaches them in a proper condition for concentration. In as much as in any type of evaporator the heating surfaces are apt to become covered with matter deposited by the juices, it will readily be understood that the best satisfaction is obtained from those evaporators whose heating surfaces are easily accessible for cleaning.

Many of our manufacturers hitherto have given the vertical apparatus the preference, one principal reason being that the tubes are easy to clean. The juice being on the inside of them the scale deposited is easily removed, whereas in the horizontal effects the juice is outside of the tubes, and in order to clean them they have to be removed from the tube heads.

In the best designed upright or so-called "Standard" evaporators each body is divided into 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. They are fitted with vertical copper tubes expanded into copper head sheets and a large central circulating tube, thus presenting a large amount of heating surface. The upper or vapor chamber of each effect is connected with the steam chamber of the next effect, so that the 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 last (third, fourth, etc.) effect a vacuum of different degree is created in each, and the juice can readily be drawn from one to the other as desired. 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.

Connected with the last body of the multiple effect is a *catchall,* the purpose of which is to prevent sugar losses by entrainment. The apparatus consists of a cylindrical cast iron box with vertical copper tubes expanded into heads and forming practically a small surface condenser. The principle on which this catchall works is as follows: As the vapors from the last body of the effect enter the catchall they come in contact with the tubes, which are cooled either by fresh water passing through them or the cool juice before it is drawn into the effect, and in this latter case the catchall may also serve as a preliminary heater. The sudden cooling of the vapors thus effected and the checking of current due to the enlarged area of the catchall causes a condensation of the vapors and a precipitation of water, which carries down with it any sugar that may have been drawn along and be suspended in the vapors. The water, together with the sugar, is drawn off at the bottom of the catchall, and may either flow back direct to the effect or first discharge into a tank.

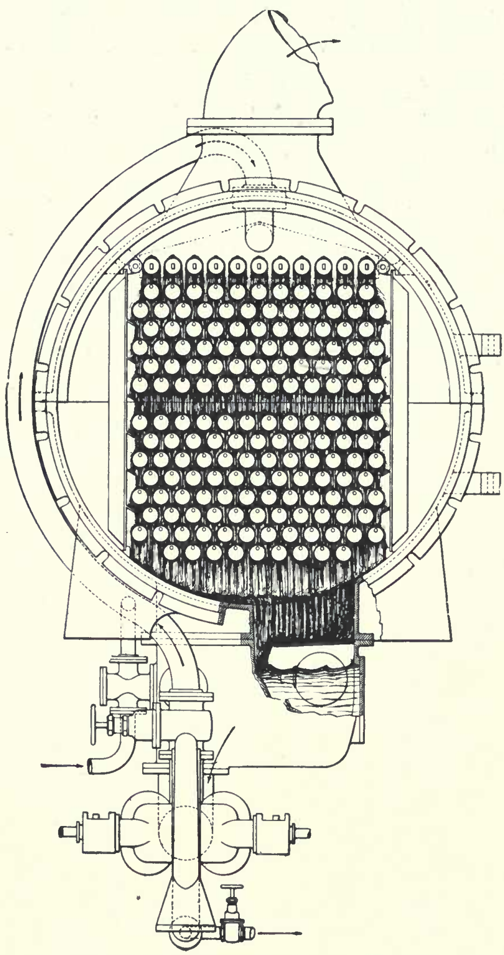
The principal point of difference between the vertical or upright, and the horizontal effects is the arrangement of the heating pipes.



LONGITUDINAL VERTICAL SECTION OF A "LILLIE" EFFECT.

The best known multiple effect of the horizontal type is the "Wellner-Jelineck." It is of elongated shape, rounded off at the top, with steam chests at either end. The heating tubes, arranged in nests, extend loosely through beveled holes in the tube plates. The body of the effect is filled with juice only to a level extending just above the tubes, leaving a space about five times the volume of the juice, preventing boiling over of the juice, while the catchall connected with the effect prevents any drops of juice that may be carried up by the steam from being carried along out of the chamber. The steam for evaporation enters through valves, and by means of return boxes is made to pass through the tubes back and forth.

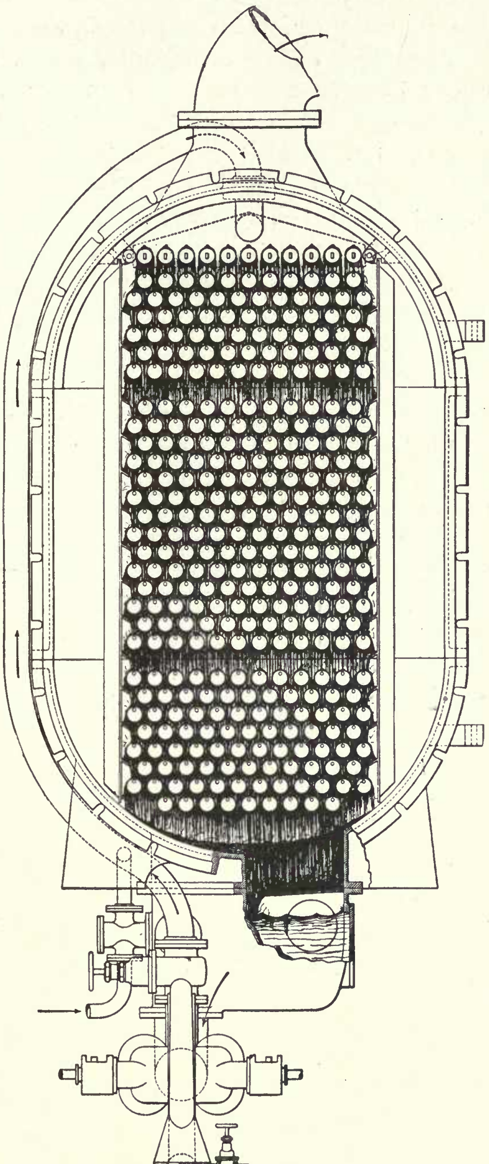
A new type of horizontal effects is represented by the Lillie evaporator, manufactured by the Sugar Apparatus Manufacturing Company of Philadelphia.



Lillie" effect, with the vapor end door removed, showing the closed ends of the tubes, and the circulation of liquor over the tubes.

The illustration on page 109 shows a longitudinal vertical section of a Lillie effect. The slightly inclined evaporating tubes open into the steam chamber through a heavy tube plate some three inches thick, in which the tubes are firmly expanded, without annealing, and by which they are sup. ported. The other ends of the tubes are closed save for a minute air vent in each, and are not fastened or supported in any way, thus allowing for longitudinal expansion and contraction independently of the body of the effect, and preventing any possibility of strains due to differences of expansion between the tubes and the body.

This illustration shows the transverse view of the battery of evaporating tubes. Above the evaporating tubes is a row of distributing tubes, each having a slot along its upper surface. The front ends are closed and their rear ends open into the manifold box on the tube plate. Above, below and on each side of the battery of tubes is a vapor space extending from the tube plate forward into the front vapor space. On the under side of the body is a wall, termed the float box, with which connects the suction of the circulating pump, a centrifugal pump underneath the apparatus. The operation is as follows: Steam, live or exhaust (or vapor from a hotter effect), supplied to the steam chamber passes into the evaporating tubes and is condensed by and causes evaporation from the juice to be concentrated, which is circulated over the evaporating tubes by the circulating pump. The resulting water of condensation flows back from the tubes into the steam chamber and through a pipe at the bottom, fitted with a trap to prevent escape of steam into the steam chamber of the next cooler effect. This passing of the water of condensation from effect to effect is an advantage resulting in greater economy.



A "Lillie" effect enlarged 100 per cent. by adding a section of Evaporating Tubes.

The juice is forced into the evaporating chamber by means of the circulating pump and flows down over the evaporating tubes in form of a shower and collects in the float box, where it is taken up again by the circulating pump and forced back into the evaporating chamber. The process is repeated until the juice has reached the desired density in the last effect, from which it discharges into the receptacle provided for it. The density of the concentrated juice, the liquor levels and the movement of the liquor into the first effect and from effect to effect are all automatically controlled by the discharge valve of the last effect.

An unique feature of the "Lillie" multiple effect is its capability of enlargement, which permits of increasing its original tube heating surface 50 % to 100 % at a comparatively small expense.

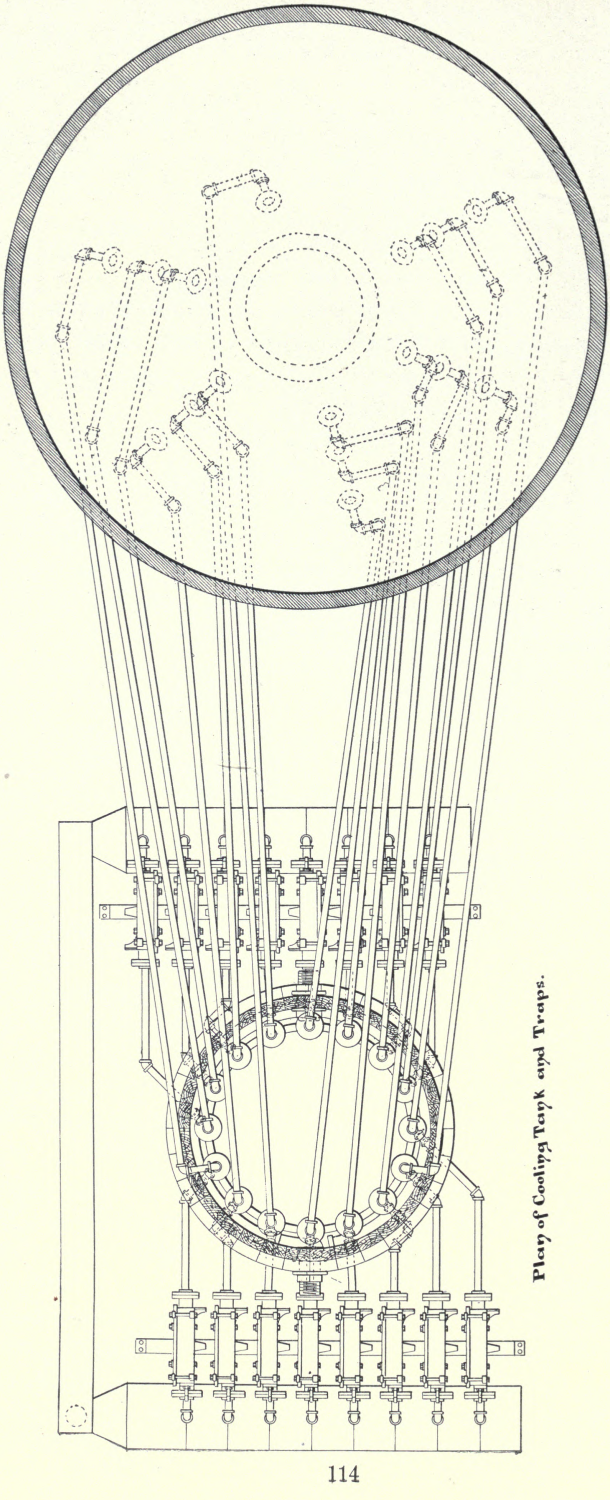
The "Lillie" is in operation in many American and European factories. Probably the largest quadruple effects ever built—(capacity of concentrating 500,000 gallons of juice 75 % in 24 hours)—have been built under the Lillie system.

BOILING TO A GRAIN WITH VACUUM PAN.

The intent and purpose of boiling under vacuum is to achieve the crystallization of the sugar contained in the juice, while keeping the more soluble parts in solution. There are two different methods of sugar boiling. One consists in continuing the process of evaporation until a hot concentrated sugar solution is obtained, which crystallizes during the cooling off; the other consists in obtaining the crystallization during the boiling process. The technical term for the former method is "boiling blank," while the latter is designated by the term "boiling grain." The difference between the two methods is the following: By the former a smaller quantity of crystals is obtained and a large quantity of syrup, while by the latter method a greater amount of crystals is obtained and less syrup. It is evident, therefore, that the latter is the more profitable and should be used exclusively for boiling first juices. Of course, in working up the syrups for the production of after products it is necessary to resort to the former method, since they contain non-sugar in such quantities as to prevent the formation of grain. The process of boiling is conducted as follows: By means of a pump the vacuum is produced. The juice is then admitted into the pan up to a certain level, while steam is admitted into the heating coils or pipes in the bottom of the pan, causing the juice to boil. The apparatus in which the concentrated juice is boiled to a thick crystallized mass, the so-called massecuite, is called the vacuum pan, and consists of a large hollow cylinder put together in sections. Formerly open pans were used, but they have been superceded everywhere by closed pans, provided with air pumps and condensers. Originally vacuum pans were built almost exclusively of copper, but of late years cast iron has been used, only the heating coils being of copper. The latter are so arranged as to prevent their vibrating during the boiling and allowing for expansion and contraction without strain. The pans are provided with condenser and catchall and a large vapor pipe leading from top of pan to condenser. This vapor pipe has an enlarged portion, forming a trap to catch any overflow, which can be returned to pan or tanks as desired. The pumps which make and maintain the vacuum, are connected with the condenser, forming what is termed a "dry" vacuum. The pan has two so-called proof sticks, for removing and testing from time to time a small quantity of the juice. There are also a number of eye-glasses arranged in different positions to enable the sugar boiler to keep a constant watch on the work going on inside the pan. A barometer and thermometer are also connected with the interior of the pan, indicating extent of vacuum and temperature of contents.

As soon as the juice has boiled down to string proof, steam pressure is decreased, reducing the temperature about ten degrees. Through the reduced tension more steam is produced, and hence a further concentration of the juice, and at the same time a lowering of the temperature. The juice not being able to absorb more sugar, part of same is separated from the juice in form of crystals.

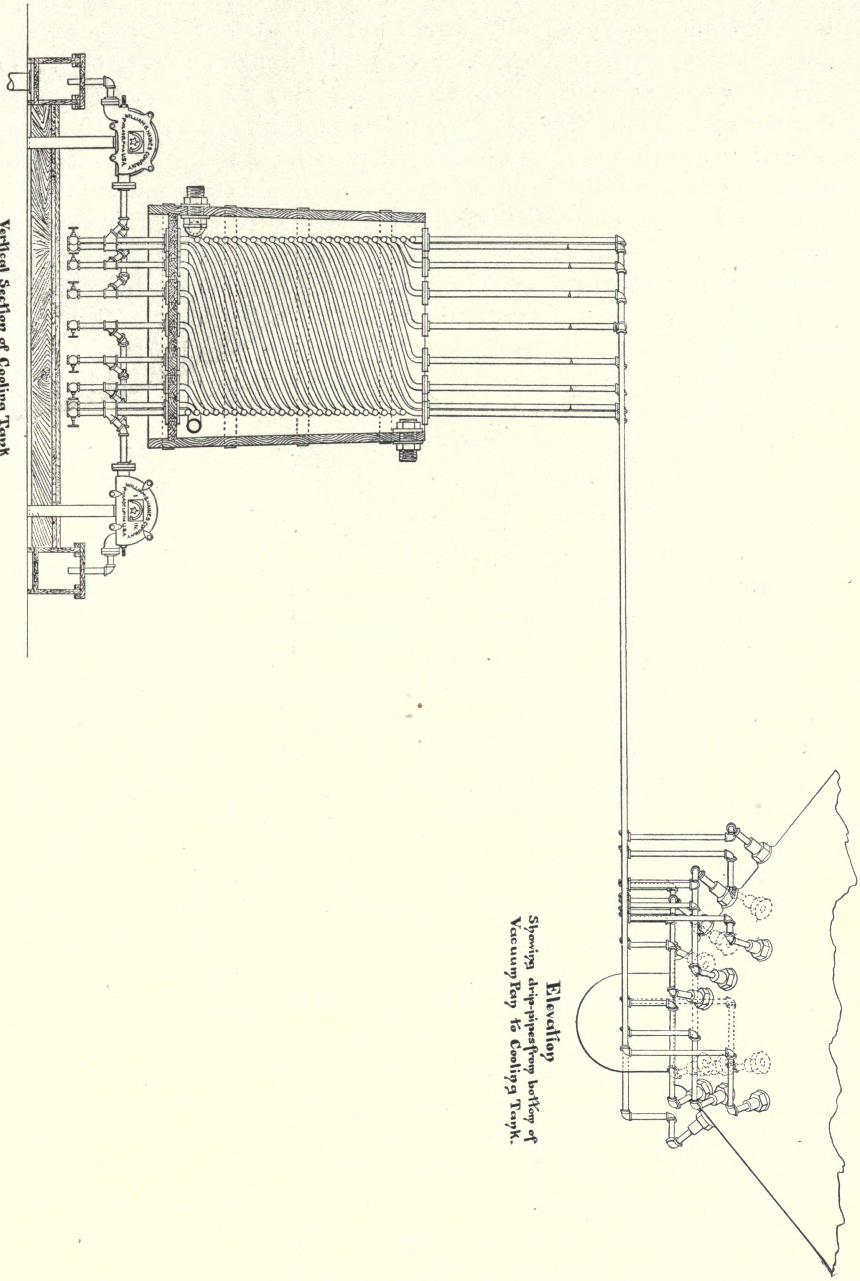
When an increase in quantity and size of the crystal is no longer observable more juice is admitted. This addition, instead of starting new grains, deposits on the first. Care must be taken that not too much fresh juice is admitted at one time, as otherwise the crystals already formed would dissolve again. The admission of fresh juice is continued until the pan is full, when its contents are passed into the mixer by means of a large valve situated in the bottom of the pan. There are various forms of pans, the main difference in their construction being in the heating device, in the older ones copper coils being used, while the newer inventions replace same by a pipe system. The question which of these is the most efficient seems to be still an open one. It has been shown in European factories, for instance, that the same amount of massecuite was boiled in the older cone-shaped coil vacuums of about 5 m. diamiter in two hours less than in those of the newer construction with a smaller diameter. On the other hand, it is claimed that the quality of a strike is not improved by quick boiling. A vacuum boiling quickly is desirable, but quick boiling in itself is bad, and for the following reasons: While it is possible to force the crystallization of the thick juice in the pan, the sugar crystals thus produced cannot be forced to combine with the crystal previously obtained. This latter process requires time. If sufficient time is not allowed, then the conditions for satisfactory crystallization of the juice are lacking, and the result will show itself in the smaller amount of first product obtained. It would, therefore, seem advisable not to try and hasten the boiling. The aim of the inventors of the newer apparatus has been to produce a pan with as large heating surface as possible, while limiting the time of boiling. To the latter class of vacuums used now in many Continental factories belongs the one invented by "Rohrig & Konig." It is constructed similar to an upright syrup tank, but with a conic wrought iron double bottom, having a circulation pipe in the middle of the steam chamber, provided with an agitator, Besides there are two arms close to the double bottom for the purpose of evenly distributing the thick juice.



Plan
Showing drip-pipes from bottom of Vacuum Pan to Cooling Tank.

Plan of Cooling Tank and Traps.

The pipes are thus arranged so as to insure a large heating surface, which can be laid quite deep. As a consequence the boiling with steam of low tension (0.1 to 0.3 Atm.) is possible, and on account of the deep level of the heating surface the formation of the grain can commence with a relatively small quantity of juice (say one-quarter of the contents



Vertical Section of Cooling Tank with Traps attached.

Elevation Showing drip-pipes from bottom of Vacuum Pan to Cooling Tank.

of the pan), an achievement not reached by other construction. The boiling is much simpler than with coil vacuums, it is claimed, and the grain obtained very even and large. The heating pipes in this pan are of brass or steel.

In the vacuum pan constructed by Wm. Greiner, Brunswick, the heating coils were originally arranged in a manner that the massecuite would always be carried again downward through an inner slot. This slot, however, was found incapable of carrying the heavy, slow-moving downward. On the newer apparatus the outer pipes are, therefore, mass thus arranged that they can be cut off at will. As long as thick juice is drawn off they remain inactive and are only put in operation later on, and thus in the main and auxiliary system all kinds of steam can be used for heating. It is claimed for this vacuum that the appearance of irregular grain during the boiling in the vacuum, due to the lack of systematic circulation of the massecuite, is done away with. Through the temporary cutting off of heating bodies the downward pressure is sufficiently increased to overcome the upward pressure produced in the axis of the cylinder vacuum.

Among other pans in favor with sugar houses may be mentioned the Wellner-Jelinck system pan, built by the Maschinenfabrik Grovenbroich; the pan of the Halle'sche Maschinenfabrik; the "Hercynia Vacuum System, Rassmus; the Rillieux, the Heckmann and the Hallstroem.

STEAM TRAPPING.

The use of steam for boiling purposes in the factory is not as well understood as it should be, nor does it have the care and consideration that it merits. The reasons for this it is needless now to discuss, but an effort will be made here to explain the importance of this subject and show the best methods to follow in order to give steam controlled appliances their highest efficiency. It has repeatedly been demonstrated by elaborate experiments that when steam is allowed to blow from the tail pipes of a vacuum pan there is a loss in heat units of from 50 to 90 % (dependent upon the actual character of the discharge), and that there is, furthermore, a loss of temperature in the pan amounting in frequent cases to as much as 25° or 30°; that is, if the steam blows from the tail pipes it is not only wasteful to the extent stated, but the contents of the pan are not kept as hot as they should be by many degrees. It is, therefore, essential to the best work that the tail pipes be properly controlled, and the accompanying drawings indicate a correct installation of Heintz's thermostatic traps for this purpose.

Until a few years ago it was the custom to attach all the tail pipes from the pan to the main drip line, which in turn was connected to a steam trap, one of the many forms of mechanical traps being ordinarily employed for this purpose. The effect of this construction was that either the trap had to be allowed to blow more or less steam in order to keep all the coils free from condensation, or this condensation backed into several of the coils so as to greatly impair their efficiency and prolong the operation of the pan unnecessarily. The usage now, however, calls for the employment of a Heintz thermostatic trap on each tail pipe, and the drawings on pages 114 and 115 give the first presentation that has ever been published of this method of handling condensation. The results of this construction are threefold: It makes the maintenance of an even temperature in the pan certain; it increases the output of the pan and secures an economy of fuel that is calculated to approximate 25 %.

In explanation of the drawings it must be borne in mind that when the condensation first sets up in the coil it has a temperature closely approaching that of the steam itself, and for this reason some pipe is required to serve as a cooling coil between the end of the tail pipe and the Heintz traps. That the length of this cooling coil may be kept within reasonable proportions, and with the further purpose of being able to practically vary the length of this cooling coil as circumstances may demand, one of the prominent sugar house engineering firms has devised a coil tank, which is shown properly connected on the same pages. A little study of the plans will indicate that whenever the volume of condensation is heaviest, calling for greater length of cooling coil, this is obtained by increasing the flow of water through the cooling tank, and vice versa, when the contents of the vacuum pan are coldest the maximum amount of water will be passed through the cooling tank, and as the operation progresses the volume of passing water can be reduced as may be necessary. It is possible with the arrangement of tail pipes and cooling tank, with the addition of a gauge glass placed on one of the tail pipes close to the vacuum pan, to keep the entrained water in the coils at practically the same level during the entire operation.

It will readily be seen that this cooling tank not only performs the office explained above, but it also makes an extremely satisfactory feed-water heater that may be used either alone or as an adjunct to another feed water heater. If it is required that the coils in the vacuum pan be instantly freed of their steam, the valves on the end of each scale leg are opened after the steam has been shut down and the pipes will be instantly discharged.

This method of controlling the drip lines from the coils is, unquestionably, the most satisfactory that has yet been devised, and the results obtained explain the popularity which it is obtaining. It must be remembered, however, that the correct size of cooling coil to employ is determined largely by the steam pressure in use on the pan—the higher the pressure the longer the coil. The manufacturers of the Heintz trap probably give precise data on this point for any steam pressure.

THE MIXER.

This apparatus is employed to allow the sugar from the vacuum pan to cool slowly and to then feed it to the centrifugals. It consists of a large V-shaped trough made of steel, with cast iron heads and partioned off in such a manner that it can be used for straight pans and seconds at the same time.

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.

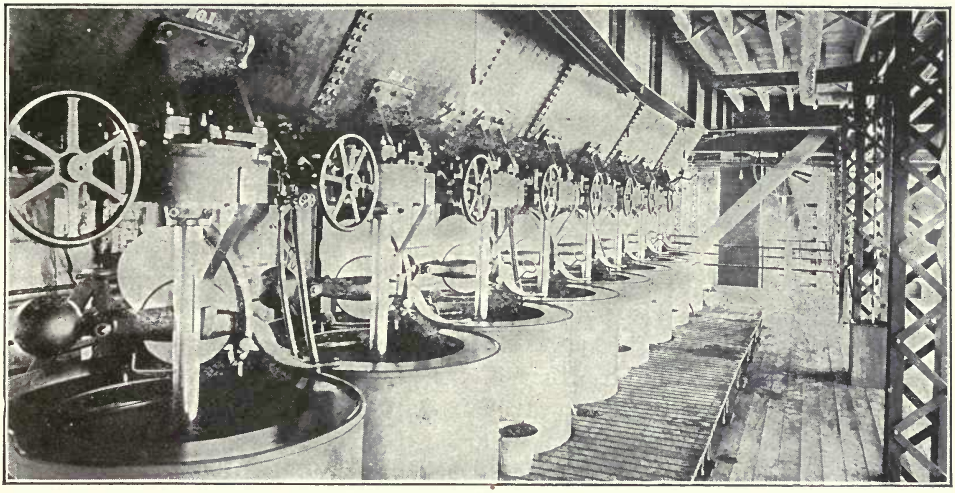
A charge of boiled juice of about 200 pounds is admitted into the centrifugals machine, which is set revolving at the rate of 1,000 revolutions per minute. At the expiration of about ten minutes the molasses is thrown off and the sugar adhering to the sides of the centrifugal removed. Thus the operation 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 sugar elevator, which in turn delivers it to the dryer or granulator, while another elevator conveys the brown sugar to the melting room. The best known types of centrifugals are the Hepworth and the Weston.

The distinctive feature of the *Hepworth type of self-balancing centrifugal* is the hanging outer casing held in a fixed relation to the revolving basket, so that one cannot swing independently of the other. The tendency of the casing to remain at rest prevents the basket from wobbling or swaying and urges it to revolve around its center, while the contents wall up evenly on all sides.

When the walling up is not perfectly even, the revolving parts do not turn about the center of the basket, the lower end of the spindle describes a circle, and the casing is forced to take up a corresponding circular motion. It is sometimes objected that considerable power must be required to set up and maintain such motion, but this is a mistake, for the motion is rarely of appreciable extent, and is never very considerable. The Hepworth effects a constant saving of friction, and, therefore, of power, through not requiring the washers in the supporting bearing to be made large enough to allow a supporting bolt to pass through their centers.

As first made the Hepworth centrifugals and their accessories were somewhat complicated and inaccessible in some of their details, but these objections have been wholly overcome by the improvements of recent years. One of the notable improvements enables the friction driving pulleys to be adjusted or provided with new friction linings without so much as stopping the shaft which supports them, and another makes the adjustment of the guide pulleys a matter of ease and certainty even to the unskilled.

As bearing on the matter of pulleys it should be noted, however, that the Hepworth machines are now made to dispense with these by substituting the water drive when the latter is preferred, but the makers believe that their latest improved belt drive is less troublesome and more effective than the water drive. The latter consists of an impulse wheel at the top of the centrifugal spindle, driven by water from a pump, and a system of pipes and tanks to deliver the water to the wheel and return it to the pumps, so as to be repeatedly used.



The above illustration shows an eight machine set of the new 40″× 24″ *Weston Patent Centrifugal Machines*, built by the American Tool and Machine Company, of Boston, as installed in many of the newer beet sugar factories in this country. The machine is noted for the excellence of its product from first sugars, which is due to the short time required to bring the machine from a state of rest to full speed.

Owing to the improved method of hanging the spindle will work equally well on first or on wagon sugars, and, with the self-balancing feature and greater stability of the basket, the machine will run steadier than ever.

All bearings, including idler and friction pulley, are provided with self-oiling arrangements, which, with the simplicity and durability of the machine, allow continued operation with a minimum of attention. The machine is very light running, requiring less horse-power to run it for the amount of work performed than any machine on the market, it is claimed.

To facilitate the rapid discharge of the load a large opening is provided in the bottom of the basket, and the valve covering the same is simple, durable and tight and easily replaced when necessary. All baskets are securely banded and are made of bronze with a brass sheet. As a brass sheet does not deteriorate, it always retains its full strength, and the machine can be run at the highest speed with safety.

Another type of centrifugal machine of American invention is the Lafferty.

DRYING THE SUGAR.

The drying of the sugar is accomplished in a granulating machine. The *granulators* installed in most of our factories are of what is known as the "*Hersey*" type. The apparatus consists of a circular steel shell, having small shelves or wings attached to its interior sides, revolving on trucks. A steam drum is located centrally within the shell, extending its entire length, and an exhaust fan is connected by means of a pipe at the upper or higher end of the machine, while a heater composed of a series of steam pipes is located at the lower end. The operation of the machine is as follows: The wet sugar as it comes from the centrifugals is fed automatically into the upper end, and as the shell slowly revolves the inner shelves pick up the sugar and drop it on the steam drum, from which it slides to the bottom, to be picked up again and dropped upon the steam drum. At the same time the heated air which is being drawn in by the exhaust pipe comes in contact with the descending sugars and absorbs and carries off the moisture. The purpose of the arrangement is to cause the sugar to pass through the entire length of the apparatus without staying too long in any one part, thus preventing the danger of burning.

The dry sugar is discharged at the lower end of the machine, where another elevator receives it and delivers it to the screens for grading it. Then it is passed through spouts according to its grade into barrels or bags. The barrels are placed upon shakers, so that the sugar is thoroughly settled into them, and when they are filled they can be headed and are ready for shipment or storage.

Some granulators are built without the inner steam drum, in place of which a greater amount of heating coils is substituted for heating the air which is sucked into the granulator.

In many of the larger factories the *system of double drying*—(Newhall patent)—is used. The sugar is partially dried in a Hersey drier, the so-called upper drum, from which it passes before any dust is formed into the lower drum or granulator, where the drying operation is completed. The effect of this is to prevent the dust from reaching the crystals and adhering to them while damp, and the result is a bright, sparkling and attractive looking sugar.

WORKING UP AFTER PRODUCTS.

The syrup or molasses obtained from the first product as above described is collected in tanks, and when a sufficient quantity 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 massecuite in constant motion, whereby the cooling is effected. By this process a brown sugar, the so-called second product, is obtained. This process is called "*crystallization in movement*," one of the most important modern improvements in sugar house work. It was first introduced about a decade ago by Dr. Johannes Bock in conjunction with the Machinenfabrik Grevenbroich. The principle on which the process is based is the increased rapidity of crystallization caused by movement of crystals in its solution. It has revolutionized the work of treating the massecuite and takes the place of the old method of keeping the after products (syrups of low purity) in large tanks or wagons to crystallize out while at rest. Its salient features are: A quicker, cheaper and cleaner method of working, resulting in a larger yield of sugar of a better quality and a less yield of molasses; no danger of inversion from heating, which is prevented by cooling, and the avoidance of an after campaign involving a large expense of labor and fuel to work up the sugar remaining in tanks weeks after the close of the main campaign.

The syrup or drains left from the first 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.

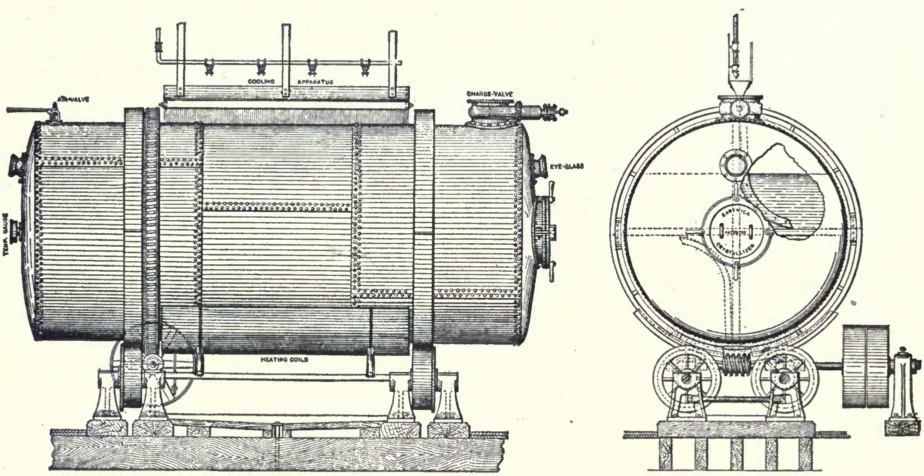
Quite a number of apparatus have been devised for crystallizing sugar in motion. The Wulff crystallizers and their many variations, the apparatus of Dr. Paul Degener and W. Grenier and the "Bergreen" are based on the principle of crystallization in motion. In the "Grosse," "Freitag" and "Sachs" processes crystals are formed either in the vacuum pan or partially in the pan and in crystallizers. In most of our factories crystallizers built on the Bock patent are used.

The new improved Eastwick crystallizer, as shown on Page 122, is found in many factories. It consists of a braced cylindrical shell with two internal curved shelves. The shell is supported on two rings, one near each end, which revolve on two pairs of roller wheels, and is set in motion by a worm gear driven by pully and belt.

The crystallizer is filled by means of a charge valve, preferably to a height about eighteen inches from the top, though it may be completely filled if desired. As soon as the crystallizer is charged the charge valve is closed and motion begun. The cylinder revolves at the velocity of about one revolution every eight or ten minutes.

As the cylinder revolves the curved shelves, which are inside and practically form buckets against the sides, pick up the massecuite as they pass through the lower position and discharge it when in the upper position, thus causing a thorough mixture of the massecuite and movement of the grain in the solution without any destruction to the grain, while at the same time the temperature of the mass is controlled by the steam coils shown underneath the shoe and the cooling apparatus above.

The cooling apparatus is very simple. The water jacket employed in other apparatus has been done away with, and the cooling is effected by wetting the outside of the shell, only sufficient water being used to dampen the shell and not to have water drip on the floor; the evaporation of the water causes a rapid decrease of temperature.



DESUGARIZING MOLASSES.

The molasses finally left is of a very low grade, and in many factories is allowed to go to the sewer or is run into the pulp. It might be used for manufacturing vinegar or blacking, but the former way of disposing of it is a hardly justifiable waste method, while the latter only pays poorly. The only proper thing to do is to take the sugar out of the molasses by some approved method. This molasses usually amounts to about 3 to 4 per cent. of the sugar content of the beet. In some factories this molasses is stored in tanks and allowed to stay in them until the next season, when such sugar as has settled to the bottom is taken out and worked over. Of course, this is rather a primitive and unsatisfactory method.

Many methods, based on different principles, such as Osmosis, Elution, Substitution, Separation, Strontian, etc., have been devised and new ones are constantly brought out.

The various *"elution" processes*, as devised by Scheibler, Stammer, Manoury and others, have not proven a success and are now-a-days in operation but in a few foreign factories.

The *Strontian process*, while admittedly a valuable one and furnishing a very pure product, has several drawbacks. In the first place the very high cost of installation, amounting according to its size to say one quarter to one half million of dollars; secondly the difficulty of obtaining Strontianite in ready quantities at reasonable prices, and thirdly the fact, that it would hardly pay even for large factories, unless they could secure the molasses from other factories to be worked up with their own.

The *substitution process* invented by Charles Steffen, has been altogether superseded by the *separation process* of the same inventor. The *new and improved* Steffen process is at present occupying the attention of all sugar men and as far as the gain of sugar is concerned according to the results of the many European factories, in which it has been introduced, seems to accomplish more than any other desugarizing process. In this process the thinned out molasses is passed with great speed under sufficient pressure through noozles, dividing the liquid into cohorent sprays or layers into a closed cylinder, called the "reaction chamber," where it is brought in contact with a stream of air, well mixed with finely pulverized lime. This lime-air is kept in constant circulation by means of exhaustors. The openings are arranged in such a manner that the sprays or layers flow through a stretch of the chamber, until they reach the outlet openings situated in the direction of the current and again pass out as closed layers or sprays through the openings from the reaction chamber with the velocity they have attained. The lime is fed in uniform quantities. The sugar solution coming in contact with the lime-charged air, part of the lime and sugar combine and are precipitated in the form of sucerate of lime, while the surplus lime is returned to circulation. The operation is repeated until all the sugar appears precipitated as insoluble sucerate of lime or tribasic lime-sugar, which is easily separated from the liquid, the latter retaining all the dissolved organic or mineral non-sugar. The separation of the sucerate of lime from the mother liquor is accomplished by a new method of filtering in specially constructed filter presses, such filtering simultaneously effecting the washing out of the sucerate of lime.

The molasses to be treated by thining out with water on the one hand and with wash lye on the other hand is reduced to liquids of different non-sugar contents, the liquid having the smallest non-sugar contents, remaining last in the filter-presses. In this manner more than 96 % of the sugar introduced to the process are obtained as saccharates of a purity of from 95 to 97 %. A further advantage of this method is found in working the syrup of the second product with quotient of 66–67 or higher and that it becomes unnecessary to make molasses or to resort to complicated methods to work up second products.

A beet sugar factory to produce white granulated will only have to boil two massecuits. The first product massecuit for the production of granulated and the second product massecuit from the wash syrup of the first for yellow grain sugar. The first massecuit consists of the diffusion juice which goes to the carbonators with the saccharate of 96% purity obtained by the wash process just described and the yellow sugar (polarizing 9.5) obtained in the swing out of the second massecuit boiled to a grain. The thin juice from the filter presses goes to the second carbonation with ½% lime, added in the form of sucerate of lime and passes from there to the third carbonation where it is sulphered until nearly neutral. The sulphured juice passes over Danêk filters into the evaporators and then in the vacuums. The first massecuit is quickly boiled to a grain, six hours sufficing for this boiling. The boiled massecuit is then centrifuged. From the centrifugals three syrups are obtained, the first and second of which are boiled to a grain in specially constructed vacuums, while the third is returned to the second carbonation. These vacuums are constructed in a manner keeping the massecuit while it is being boiled to a grain constantly agitated. The boiling is commenced with the second syrup so as to start the formation of the grain (crystals); the first syrup is gradually added till the boiling is completed, which requires from 24 to 28 hours. When the second product is thus finished in the boiling it is centrifuged, returning a beautiful large grained yellow sugar polarizing 95 by about 90 rendement.

The wash syrup of the yellow sugar has a purity coefficient of 64 to 66 and as already described, is returned to the first and second carbonation. In this manner 90 to 92% of beautiful white crystallized sugar (granulated) is obtained out of 100% sugar in the beet—in other words the manufacturer gets pretty near all the sugar that can be obtained from the beet. Furthermore, in addition to its highly satisfactory results both as regards *quantity* and *quality* of the refined product it furnishes, it compares most favorably in simpleness of manipulation and in point of cost, (installation and running expenses) with any other method now in use.

The *Osmose process*, as originally invented by Dubrunfant and which is still used in many of the smaller factories in Europe, requires comparatively speaking a very small investment and small running expenses, but the results are likewise limited. But not only is the amount of sugar obtainable by the old Osmose process limited, even if the osmosing operation is extented, there will always be left a considerable amount of osmosed molasses. Another drawback of this method is that the beet juices into which the osmose product is introduced are more or less unfavorably affected as regard purity and color.

These drawbacks have been practically overcome by the *Vallez Triple Osmose Process*, recently invented and already introduced in a number of our beet sugar factories. In its general instruction the Vallez triple osmose process very much resembles the well-known construction of osmose apparatus. In the Vallez osmogenes the total number of frames is divided into three equal parts and each of the three parts acts, so to say, as a separate apparatus; the molasses entering the osmogenes at one end, the water at the other.

The total number of frames are, as mentioned above, separated into three equal parts by a specially constructed frame which conducts the liquids from one compartment to the next. This permits a more complete purification of the molasses; the molasses entering one end of the apparatus encounters the water already charged, to a certain extent, with impurities, and upon arriving at the last compartment, from where the molasses leaves the apparatus, it is brought in contact with fresh water which naturally has a greater action on the molasses which has been partly purified in the previous compartments. Thus, more salts can be eliminated from the molasses with less water, resulting in a higher purity of the osmosed molasses, and lower purity of the osmose water.

The osmose apparatus being divided into three compartments, each compartment acting as a separate osmogene, the circulation of both liquids is better, as they are more evenly distributed into the different frames. The natural consequenc of this circulation is a more complete and even utilization of the parchment paper, which will resist longer and at the same time give better results.

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 mitrogen, this pulp would represent 44 units of feeding value.

Pulp driers, which form part of the installation in all European factories are now being introduced in some of our factories. These driers are coustructed similar to a granulator. The pulp is cut into small pieces and forced by means of pumps through filterpresses after sufficient water having been added to enable the pumps to handle it. From the presses it passes into the drier, then to a set of rollers where it is ground as fine as bran. It is then bagged or baled for shipment. Ready market for the product which can be sold at $8.00 and more per ton at factory is found abroad. The installation (including filterpresses, pumps, etc.,) for a 500 ton factory would amount to about $16,000. Additional cost of building $5,000. The total cost for fuel, labor, bags, etc., including interest is given as about $55.00, while the product obtained out of 500 tons ordinary pulp is 29 tons.

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 requirements", the amount of materials used, price of beets and wages paid, and duration of campaign. 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 per cent. at $3.00 per ton	.36	
Limestone, 10 per cent. 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, stationery and incidentals, in round figures	50,000	
Total	$353,000	
On an outturn of say 10 per cent., 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 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 above 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 % coal per ton of beets.

Hence, if as has been the case in some factories in this country, 23 % of coal are used, this means a difference of 14 % 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 $\frac{21}{100}$, or say $\frac{1}{5}$ 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 $\frac{6}{1000}$ cent. per lb. granulated sugar.

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. In this connection a few words in regard to boiler plants.

In deciding on the *boiler plant*, the following vital points should be considered, viz: Simplicity in construction, accessibility for cleaning and inspection and easy and quick repairing in case of accident.

A very important improvement introduced in modern boiler plants consist in an automatic feeding device of the furnaces, whereby the coal is delivered directly from bins placed above the boilers into hoppers and fed regularly to the fires by means of automatic smoke consuming stokers. These bins generally have a storage capacity to feed the furnaces for a period of not less than 24 hours without refilling. Mechanical cross conveyors in direct connection with the coal storage sheds of suitable capacity, generally not less than 100 cars, are used for filling the bins and also for removing the ashes, dumped from the ashpits, from the boiler house to an elevator which takes them up to a receiving bin, from which they are spouted off into cars or carts to be hauled away. This process involves great economy not only in the amount of coal used, but also in the handling of the coal and ashes.

A fuel economizer placed in the smoke flue between the boilers and the shack is another important improvement of a modern boiler plant.

In previous chapters attention has already been drawn to the necessity of *economizing in steam and water*. The consumption of water depending of course upon size of factory runs into the millions of gallons. Where the factory is located in near proximity to a river or lake front, economy in quantity of water used is not of such vital importance, than in such cases where the factory has to rely for its suply on artesian wells. It is not an uncommon occurrence that wells become suddenly dry, hence the water system should always be arranged with a view of economizing as much as possible. There are a number of methods, and new ones are constantly devised whereby the total quantity of water consummed is considerably reduced by returning to the factory all the diffusion and beetwasher water, after it has been cleansed of its impurities. This question of economizing in steam and water has of course a direct bearing on the cost of the sugar, hence should be carefully looked into by the factory builder.

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 pound 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.

Table showing the profits per season, also the difference in cost per pound of granulated sugar, according to yield and quality:

Yield per ton Beets	9 pr. ct.=180 lbs.		10 pr. ct.=200 lbs.		11 pr. ct.=220 lbs.		12 pr. ct.=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
	Cents	Dollars	Cents	Dollars	Cents	Dollars	Cents	Dollars
350	3.89	70.050	3.50	105.050	3.20	140.050	2.92	175.050
400	3.79	87.200	3.41	127.200	3.10	167.200	2.84	207.200
500	3.65	121.500	3.29	171.500	2.99	221.500	2.74	271.500
600	3.54	155.800	3.20	215.800	2.91	275.800	2.67	335.800
700	3.49	190.100	3.14	260.100	2.86	330.100	2.62	400.100
800	3.44	224.400	3.10	304.400	2.82	384.400	2 58	464.400
900	3.40	258.700	3.06	348.700	2.78	438.700	2.55	528.700
1000	3.37	293.000	3.04	393.000	2.76	493.000	2.53	593.000
1250	3.32	378.750	2.98	503 750	2.71	628.750	2.49	753.750
1500	3.28	464.500	2.95	614.500	2.68	764.500	2.46	914.500
2000	3.23	636.000	2.91	836.000	2.65	1.036.000	2.42	1,236.000

Campaign duration, also a factor in deciding the cost of the sugar depends of course primarily on the beet supply, hence the factory management should see to it that there is never any lack of beets. The beet sheds should be built large enough to hold a supply of a couple of weeks so as to provide for emergencies in case unforseen circumstances—(for inst. sudden change in weather making roads impassable)—should cause a temporary stoppage in the deliveries by the contracting farmers. In order to make a factory pay well, the campaign should be condensed in the smallest possible space of time, the factory working continuously at its fullest capacity. From the moment the factory is started, in other words from the first day beets are sliced, until the last day of the campaign the factory must work without stoppage. A side from the fact, that the running expenses will be proportionately increased through the drawing out of a campaign, there is the additional danger of the juice in the waiting tanks fermenting. For this and other reasons it is out of question to close the factory even on Sundays. To prevent serious losses it must be kept running day and night and from start to finish of campaign.

As already mentioned in a previous chapter in some states a bounty is granted to the beet sugar factories, part of which goes to the beet grower and part to the sugar factory, and, 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.

CONCLUSION.

The beet sugar industry is still in its infancy and both in the field work and factory work much will have to be done yet, before the best results will be obtainable. In fact we may be said to be still in the experimental stage. Although we have the advantage of the dearly paid for experience of the European beet grower and sugar manufacturer, covering nearly a century, at our command there remains much to be done in the way of simplifying the mechanical and chemical methods in the factory and devising means whereby the hand labor in the fields may be reduced, if not entirely be done away with.

But American inventive genius has ever been equal to any task and it surely will solve the problems which confront this new industry. Looking at the results so far obtained, we certainly have every reason to feel proud of the progress made, which forecasts a brilliant future.

But above all and this is my concluding advise: Farmer and factory must work hand in hand. The farmer produces the sugar in the field and the manufacturer extracts it at the factory. Their interests are so closely interwoven that a false step on either part would work detrimental to the interests of both. The farmer would not find it profitable to grow sugar beets without the factory, while the factory on the other hand could not exist without being furnished the necessary supply of beets of the right quality by the farmer. Friendly relations between the farmer and the factory are therefore absolutely necessary and essential to success. The farmer should study the interest of the factory, same as the factory should study his, for both are identical. Let this be the thought and purpose of those who engage in the industry on either side.

END.

Table of Contents.

Appendix.

DIRECTORY

OF

MANUFACTURERS OF SUGAR MACHINERY AND APPARATUS, BEET FARMING TOOLS AND IMPLEMENTS, GROWERS AND DEALERS IN BEET SEED, MANUFACTURERS AND DEALERS IN FERTILIZERS AND CHEMICALS, ETC.

Air Compressors and Blowing Engines.

American Steam Pump Co., Battle Creek, Mich. (See ad.)
A. S. Cameron Steam Pump Works, New York, N. Y.
Connersville Blower Co., Connersville, Ind.
J. B. & J. M. Cornell, New York, N. Y. (See ad.)
M. T. Davidson, New York, N. Y.
The Dickson Mfg. Co., Scranton, Pa.
Garden City Fan Co., Chicago, Ill.
Gardner Governor Co., Quincy, Ill.
Guild & Garrison, Brooklyn, N. Y.
Knowles Steam Pump Works, Boston, Mass.
Laidlaw-Dun-Gordon Co., Cincinnati, O.
Norwalk Iron Works, So. Norwalk, Conn.
Wm. R. Perrin & Co., Chicago, Ill. (See ad.)
L. Schutte & Co., Philadelphia, Pa.
Snider-Hughes Co., Cleveland, O.
Stilwell-Bierce Smith Vaile Co., Dayton, O.
B. F. Sturtevant Co., Boston, Mass.

Asbestos and Roofing Materials.

Advance Packing Supply Co., Chicago, Ill.
Chicago Fire Proof Covering Co., Chicago, Ill.
The H. W. Johns Mfg. Co., New York, N.Y.
Manville Covering Co., Milwaukee, Wis.
E. A. Mason, New York, N. Y.
Norristown Covering Co., Ltd., Norristown, Pa.
Western Roofing and Supply Co., Chicago, Ill.

Automatic Beet Scales.

The Hennef Engineering Works, C. Reuther & Reisert, Ltd., Hennef-on-Sieg, Gy. (See ad.)

Automatic Weighing and Packing Machines.

New England Aut. Weigh. Mach. Co., Boston, Mass.
The Pratt & Whitney Co., Hartford, Conn.

Bag Filters.

J. B. & J. M. Cornell, New York, N. Y. (See ad.)
Robert Deely & Co., New York, N. Y.
Haubtmann & Loeb Co., Ltd., New Orleans, La.
Krajewski-Pesant Co., New York, N. Y.
Fred. W. Wolf Co., Chicago, Ill. (See ad.)
R. D. Wood & Co., Philadelphia, Pa.

Belting.

Boston Belting Co., Boston, Mass.
Gutta Percha & Rubber Mfg. Co., New York, N. Y.
Main Belting Co., Chicago, Ill.
N. Y. Leather Belting Co., New York, N. Y.
Chas. A. Schieren & Co., New York, N. Y.
Schultz Belting Co., St. Louis, Mo.

Belt Dressing.

Jos. Dixon Crucible Co., Jersey City, N. J.
E. F. Houghton & Co., Philadelphia, Pa.
Stephenson Mfg. Co., Albany, N. Y.
The White & Bagley Co., Wooster, Mass.

Boilers.

Abendroth & Root Mfg. Co., New York, N. Y.
Atlas Engine Works, Indianapolis, Ind.
Babcock & Wilcox Co., New York, N. Y.
Edw. P. Allis & Co., Milwaukee, Wis.
Bass Foundry & Machine Works, Fort Wayne, Ind.
Bates Machine Co., Joliet, Ill.
Buffalo Forge Co., Buffalo, N. Y.
Chandler & Taylor Co., Indianapolis, Ind.
Coatesville Boiler Works, Coatesville, Pa.
C. & G. Cooper Co., Mt. Vernon, O.
Detroit Water Tube Boiler Co., Detroit, Mich.
Erie City Iron Works, Chicago, Ill.
Fairbanks, Morse & Co., Chicago, Ill.
Filer & Stowell Co., Milwaukee, Wis.
Frick Company, Waynesboro, Pa.
Griffith & Wedge Co., Zanesville, O.
Hazelton Boiler Co., New York, N. Y.
Heine Safety Boiler Co., St. Louis, Mo.
Hooven, Owens & Rentschler Co., Hamilton, Ohio.
Illinois Steam Boiler Works, Chicago, Ill.
Kingsford Foundry and Machine Works, Oswego, N. Y.
Kroeschell Bros. Co., Chicago, Ill.
Lane & Bodley Co., Cincinnati, O.
Leonard & Wright, Chicago, Ill.
McNeil Boiler Works, Akron, O.
John Mohr & Sons, Chicago, Ill.
Murray Iron Works Co., Burlington, Ia.
N. Y. Safety Steam Power Co., New York, N. Y.
Power Installation Co., Buffalo, N. Y.
Springfield Boiler & Mfg. Co., Chicago, Ill.
The Stirling Co., Chicago, Ill.
Tudor Boiler Mfg. Co., Cincinnati, O.
Titusville Iron Co., Titusville, Pa.
Robt. Wetherill & Co., Chester, Pa.
Wickes Brothers, Saginaw, Mich.
M. Zier & Co, New Albany, Ind.

Boiler Compounds.

Dearborn Drug & Chemical Co., Chicago, Ill.
Keystone Chem. Mfg. Co., Camden, N. J.
J. H. Parsons Chem. Co., Chicago, Ill.
Pittsb. Boiler Scale Resolvent Co., Pittsburgh, Pa.
Scale Solvent Co., New York, N. Y.

Boiler and Pipe Coverings.

Advance Packing and Supply Co., Chicago, Ill.
Manville Covering Co., Milwaukee, Wis.
The H. W. Johns Mfg. Co., New York, N. Y.
Nonpareil Cork Mfg. Co., Bridgeport, Conn.

Boiler Tube Cleaners.

Chicago Boiler Cleaner Co., Chicago, Ill.
A. W. Chesterton & Co., Boston, Mass.
Lagonda Mfg. Co., Springfield, O.
The Wm. B. Pierce Co., Buffalo, N. Y.
Jas. L. Robertson & Sons, New York, N. Y.
John H. Vorhees, Brooklyn, Y. N.

Brass, Copper and Iron Work.

American Copper, Brass and Iron Works, Chicago, Ill.
Ford Bros. & Co., Philadelphia, Pa.
Geo. P. Harris & Bro., Chicago, Ill.
Haubtman & Loeb Co., Lim., New Orleans, La.
J. B. & J. M. Cornell, New York, N. Y. (See ad.)
Jos. Oat & Sons, Philadelphia, Pa. (See ad.)
Phila. Coppersmithing Co., Philadelphia, Pa. (See ad.)
Wm. Toepfer & Sons, Milwaukee, Wis.
Frank Trenkhorst, Chicago, Ill.
John Turl's Sons, New York, N. Y.
Otto Zobler Copper and Iron Works, Chicago, Ill.

Centrifugal Machines.

American Tool and Machine Co., Boston, Mass. (See ad.)
J. B. & J. M. Cornell, New York, N. Y. (See ad.)
Haubtman & Loeb Co., Ltd., New Orleans, La.
S. S. Hepworth Co., New York, N. Y. (See ad.)
Krajewski-Pesant Co., New York, N. Y.
H. W. Lafferty, Philadelphia, Pa. (See ad.)
Henry O. Morris, Philadelphia, Pa.

Chemical and Physical Apparatus.

Eimer & Amend, New York, N. Y. (See ad.)
Richards & Co., Ltd., Chicago, Ill. (See ad.)
E. H. Sargent & Co., Chicago, Ill.

Condensers (See also Feed Water Heaters, etc.)

Conover Mfg. Co., New York, N. Y.
J. B. & J. M. Cornell, New York, N. Y. (See ad.)
M. T. Davidson, New York, N. Y.
Jas. Reilly Repair and Supply Co., New York, N. Y.
L. Schutte & Co., Philadelphia, Pa.
Stilwell-Bierce & Smith Vaile Co., Dayton, O.
Wheeler Condenser and Eng. Co., New York, N. Y.

Conveying and Hoisting Machinery.

Brown Hoisting Machinery Co., Cleveland, O.
H. W. Caldwell & Son Co., Chicago, Ill. (See ad.)
Dodge Mfg. Co., Mishawaka, Ind. (See ad.)
Exeter Machine Works, Pittston, Pa.
Jeffrey Mfg. Co., Columbus, O. (See ad.)
Lidgerwood Mfg. Co., New York, N. Y.
Link-Belt Machinery Co., Chicago, Ill. (See ad.)
John A. Mead Mfg. Co., New York, N. Y.

Consulting Engineers.

The Eastwick Engin. Co., Ltd., New York, N. Y. (See ad.)
Americ. Constr. and Supply Co., New York, N. Y. (See ad.)
J. M. Cooper, New Orleans, La.
T. H. Mueller, New York, N. Y.
Oxnard Construction Co., New York, N. Y. (See ad.)
E. Salich & Co., Chicago, Ill. (See ad.)
Percy A. Sanguinetti, New York, N. Y.

Corliss Engines.

Edw. P. Allis & Co., Milwaukee, Wis.
Ames Iron Works, Chicago, Ill.
Atlas Engine Works, Indianapolis, Ind.
Babcock & Wilcox Co., New York, N. Y.
Ball Engine Co., Erie, Pa.
Bass Foundry and Machine Works, Fort Wayne, Ind.
Bates Machine Co., Joliet, Ill.
The Brownell Co., Chicago, Ill.
Chandler & Taylor Co., Indianapolis, Ind.
C. & G. Cooper Co., Mt. Vernon, O.
Dickson Mfg. Co., Scranton, O.
Fishkill Landing Mach. Co., Fishkill, N. Y.
Filer & Stowell Co., Milwaukee, Wis.
Fairbanks, Morse & Co., Chicago, Ill.
Fitchburg Steam Engine Co., Fitchburg, Mass.
Frick Company, Waynsboro, Pa.

Griffith & Wedge Co., Zanesville, O.
Harris-Corliss Engine Works, Providence, R.I.
Harrisburg Foundry and Mach. Works, Harrisburg, Pa.
Hewes & Phillips Iron Works, Newark, N. J.
Hooven, Owens & Rentschler Co., Hamilton, O.
International Power Co., Providence, R. I.
Lane & Bodley Co., Cincinnati, O.
Murray Iron Works, Burlington, Ia.
Newburgh Ice Machine and Engine Co., Newburgh, N. Y.
Penna Iron Works Co., Philadelphia, Pa.
Rusell Engine Co., Chicago, Ill.
St. Louis Iron and Machine Works, St. Louis, Mo.
Vilter Mfg. Co., Milwaukee, Wis.
Watts-Campbell Co., Newark, N. J.
Robt. Wetherill & Co., Chester, Pa.
Wickes Brothers, Saginaw, Mich.

Crystallizers.

J. B. & J. M. Cornell, New York, N. Y. (See ad.)
Robt. Deely & Co., New York, N. Y.
Eastwick Engineering Co., Ltd., New York, N. Y. (See ad.)
Maschinenfabrik Grevenbroich, New York, N. Y. (See ad.)
Otto Zobler Copper and Iron Works, Chicago, Ill.

Designers and Builders of Sugar Machinery and Complete Beet Sugar Plants.

American Construction and Supply Co., New York, N. Y. (See ad.)
American Copper, Brass and Iron Works, Chicago, Ill.
Bartlett, Hayward & Co., Baltimore, Md. (See ad.)
H. W. Caldwell & Son Co., Chicago, Ill. (See ad.)
J. B. & J. M. Cornell, New York, N. Y. (See ad.)
Dayton Globe and Iron Works, Dayton, O.
Frank De Connick, San Francisco, Cal. (Representing Braunschw. Maschinenbau-Anstalt, Brunswick, Gy.)
E. H. Dyer & Co., Cleveland O. (See ad.)
Robt. Deely & Co. New York, N. Y.
Eastwick Engineering Co., Ltd., New York, N. Y. (See ad.)
Kilby Manufacturing Co., Cleveland, O. (See ad.)
Maschinenfabrik Grevenbroich, New York, N. Y. (See ad.)
Murphy Iron Works, New Orleans, La.
Geo. M. Newhall Engin. Co., Ltd., Philadelphia, Pa.
Oxnard Construction Co., New York, N. Y.
Risdom Iron Works, San Francisco, Cal.
F. Salich & Co., Chicago, Ill. (See ad.)
Walburn-Swenson & Co., Chicago, Ill.
Whitney Iron Works Co., New Orleans, La.
Fred. W. Wolf Co., Chicago, Ill. (See ad.)

Electric Plants, Motors, Dynamos, Etc.

Bullock Electric Mfg. Co., Cincinnati, O.
Chicago Edison Co., Chicago, Ill.
Commercial Electric Co., Indianapolis, Ind.
Commonwealth Electric Co., Chicago, Ill.
Eagle Electrical Work, Peoria, Ill.
Eddy Electric Mfg. Co., Chicago, Ill.
Guarantee Electric Co., Chicago, Ill.
Gregory Electric Co., Chicago, Ill.
Holtzer-Cabot Electric Co., Chicago, Ill.
Lane & Bodley Co., Cincinnati, O.
Northern Electrical Mfg. Co., Madison, Wis.
Triumph Electric Co., Cincinnati, O.
Westinghouse Electric and Mfg. Co., Pittsburg, Pa.

Elevating, Conveying and Power Transmitting Machinery.

American Tool and Machine Co., Boston, Mass. (See ad.)
The Aultman Company, Canton, O.
Buhl Malleable Co., Detroit, Mich.
H. W. Caldwell & Son Co., Chicago, Ill. (See ad.)
Dodge Manufacturing Co., Mishawaka, Ind. (See ad.)
Heyl & Patterson, Pittsburg, Pa.
Jeffrey Mfg. Co., Columbus, O. (See ad.)
Link-Belt Machinery Co., Chicago, Ill. (See ad.)
Morse, Williams & Co., Philadelphia, Pa.
Webster Manufacturing Co., Chicago, Ill.
Weller Manufacturing Co., Chicago, Ill.

Engine Registers and Counters.

The Bristol Co., Waterbury, Conn.
Crosby Steam Gauge and Valve Co., Boston, Mass.
Hohmann & Maurer Mfg. Co., Rochester,
The Lunkenheimer Co., Cincinnati, O.
Schaeffer & Budenberg, Brooklyn, N. Y.

Evaporating Apparatus. (See also Vacuum Pans, Etc.)

J. B. & J. M. Cornell, New York, N. Y.
Robert Deely & Co., New York, N. Y.
Dayton Globe and Iron Works, Dayton, O.

Krajewski-Pesant Co., New York, N. Y.
Jos. Oat & Sons, Philadelphia, Pa.
Philadelphia Coppersmithing Co., Philadelphia, Pa. (See ad.)
Jas. Reilly Supply and Repair Co., New York, N. Y.
The Sugar Apparatus Mfg. Co., Philadelphia, Pa. (See ad.)
John Turl's & Sons, New York, N. Y.
Otto Zobler Copper and Iron Works, Chicago, Ill.

Fans, Dust Collectors, Furnace Feeders.

Allington & Curtis Mfg. Co., Saginaw, Mich.
Buffalo Forge Co., Buffalo, N. Y.
Garden City Fan Co., Chicago, Ill.

Feedwater Heaters, Purifiers and Condensers.

Bates Machine Co., Joliet, Ill.
Wm. Baragwanath & Son, Chicago, Ill.
J. B. Davis & Son, Hartford, Conn.
Goubert Mfg. Co., New York, N. Y.
Green Fuel Economizer Co., Mattawan, N. Y.
Harrison Safety Boiler Works, Philadelphia, Pa.
Hoppes Mfg. Co., Springfield, O.
Chas. Jacobs & Co., Boston, Mass.
Frank L. Patterson, New York, N. Y.
P. G. H. Feed Water Heater Co., Pittsburgh, Pa.
The Stilwell-Bierce & Smith-Vaile Co., Dayton, O.
Warren, Webster & Co., Camden, N. J.
Wheeler Condenser and Eng. Co., New York, N. Y.
Whitlock Coil Pipe Co., Hartford, Conn.

Feedwater Regulators.

Crosby Steam Gauge and Valve Co., Boston, Mass.
Hoppes Mfg. Co., Springfield, O.
The Lunkenheimer Co., Cincinnati, O.
The Williams Gauge Co., W. Pittsburg, Pa.

Filter Cloths.

Robert Deely & Co., New York, N. Y.
Wm. R. Perrin & Co., Chicago, Ill. (See ad.)
Stilwell-Bierce & Smith-Vaile Co., Dayton, Ohio.

Filter Press Plates.

The Robert Aitchison Perforated Metal Co., Chicago, Ill.
J. B. & J. M. Cornell, New York, N. Y.
Wm. R. Perrin & Co., Chicago, Ill. (See ad.)

Filter Presses.

J. B. & J. M. Cornell, New York, N. Y.
Davis, Johnson & Co., Chicago, Ill.
Farrel Foundry & Machine Co., Ansomia, Con.
Haubtman & Loeb Co., Ltd., New Orleans, La.
Krajewski-Pesant Co., New York, N. Y.
Link-Belt Machinery Co., Chicago, Ill. (See ad.)
Wm. R. Perrin & Co., Chicago, Ill. (See ad.)
The Stilwell-Bierce & Smith-Vaile Co., Dayton, O.
Whitney Iron Works Co., New Orleans, La.

Fire Brick, Blocks, Tiles, Etc.

American Fire Brick Works, Philadelphia, Pa.
Bargener Cement Co., Philadelphia, Pa.

Fire Felt Coverings for Steam Pipe, Boilers, Etc.

Chicago Fire Proof Covering Co., Chicago, Ill.
H. W. Johns Mfg. Co., New York, N. Y.
Manville Covering Co., Milwaukee, Wis.
Sall Mountain Asbestos Mfg. Co., Chicago, Ill.
Western Roofing and Supply Co., Chicago, Ill.

Gas and Sulphur Blowers.

American Blower Co., Detroit, Mich.
Babcock & Wilcox Co., New York, N. Y.
Connersville Blower Co., Connersville, Ind.
Guild & Garrison, Brooklyn, N. Y.
Knowles Steam Pump Works, Boston, Mass.
Snider-Hughes Co., Cleveland, O.
Stilwell-Bierce & Smith-Vaile Co., Dayton, Ohio.
B. F. Sturtevant & Co., Boston, Mass.

Gas, Gasoline and Oil Engines.

Chicago Water Motor and Fan Co., Chicago, Ill.
Davis, Johnson & Co., Chicago, Ill.
Foos Gas Engine Co., Springfield, O.
Fairbank's Morse & Co., Chicago, Ill.
Middletown Mach. Co., Middletown, O.
A. Mietz, New York, N. Y.
New Era Iron Works, Dayton, O.
Pierce Engine Co., Racine, Wis.
Priestman & Co., Philadelphia, Pa.
Stover Engine Works, Freeport, Ill.
J. Thompson & Sons Mfg. Co., Beloit, Wis.
Weber Gas and Gasoline Eng. Co., Kansas City, Mo.

Graphite.

Jos. Dixon Crucible Co., Jersey City, N. J.
Detroit Graphite Mfg. Co., Detroit, Mich.

Granulators and Driers.

J. B. and J. M. Cornell, New York, N. Y.
Hersey Mfg. Co., So. Boston, Mass.
Geo. M. Newhall Engineering Co., Ltd., Philadelphia, Pa.

Laboratory Outfits.

Eimer & Amend, New York. N. Y. (See ad.)
Richards & Co., Ltd., Chicago, Ill. (See ad.)
E. H. Sargent & Co., Chicago, Ill.

Laundry Machinery.

American Laundry Machinery Co., Chicago, Ill.
Sinclair, S. H. Company, Chicago, Ill.
Troy Laundry Machinery Co., New York, N.Y.

Machine Tools.

American Tool Works Co., Cincinnati, O.
Hill, Clarke & Co., Boston, Mass.
Manning, Maxwell & Moore, Chicago, Ill.
Niles Tool Works Co., New York, N. Y.
Pond Machine Tool Co., Plainfield, N. J.

Pulp Conveyors.

H. W. Caldwell & Son Co., Chicago, Ill. (See ad.)
Dodge Mfg. Co., Mishawaka, Ind. (See ad.)
The M. Garland Co. Bay City, Mich.
Link-Belt Mfg. Co., Chicago, Ill. (See ad.)

Pulp Driers.

American Constr. Supply Co., New York, N. Y. (See ad.)
The Turney Drier Co., Louisville, Ky.

Pumps and Pumping Machinery.

Amer. Steam Pump Co., Battle Creek, Mich.
W. D. Allen Mfg. Co., Chicago, Ill.
W. M. Blake Steam Pump Co., Fitchburg, Mass.
Barr Pumping Engine Co., Philadelphia, Pa.
A. T. Cameron Steam Pump Works, New York, N. Y.
M. T. Davidson, New York, N. Y.
J. B. Davis & Son, Hartford, Conn.
The Deane Steam Pump Co., Holyoke, Mass.
Epping-Carpenter Co., Pittsburg, Pa.
Erwin & Welch, Chicago, Ill.
Fairbanks, Morse & Co., Chicago, Ill.
Foster Pump Works, Brooklyn, N. Y.
Guild & Garrison, Brooklyn, N. Y.
Goulds Mfg. Co., Seneca Falls, N. Y.
Heisler Pumping Engine Co., Erie, Pa.
Henion & Hubbel, Chicago, Ill.
Kingsford Foundry and Machine Works, Oswego, N. Y.
Knowles Steam Pump Works, Boston, Mass.
Laidlaw-Dun-Gordon Co., Cincinnati, O.
Lawrence Machine Co., Lawrence, Mass.
John H. McGowan Co., Cincinnati, O.
Scranton Steam Pump Co., Scranton, Pa.
Snider-Hughes Co., Cleveland, O.
Taber Pump Co., Buffalo, N. Y.
Stilwell-Bierce & Smith-Vaile Co., Dayton, Ohio.
Warren Steam Pump Co., Warren, Pa.
Henry R. Worthington, New York, N. Y.

Pressure Gauges, Water Gauges, Etc.

American Steam Gauge Co., Chicago, Ill.
American Steam Gauge and Valve Co., Boston, Mass.
Ashton Valve Co., New York, N. Y.
Ashcroft Mfg. Co., Boston, Mass.
The Bristol Co., Waterbury, Conn.
Crosby Steam Gage and Valve Co., New York, N. Y.
The Fairbanks Co., New York, N. Y.
Hohmann & Maurer Mfg. Co., Rochester, N. Y. (See ad.)
The Lunkenheimer Co., Cincinnati, O.
Schaeffer & Budenberg, Brooklyn, N. Y. (See ad.)

Rope Transmissions.

A. W. Caldwell & Son Co., Chicago, Ill. (See ad.)
Christiana Machine Co., Christiana, Pa.
Dodge Mfg. Co., Michawaka, Ind. (See ad.)
W. A. Jones Foundry and Machine Co., Chicago, Ill.
Link-Belt Mfg. Co. (See ad.)
T. B. Wood Sons, Chambersbury, Pa.

Reducing Valves.

Automatic Red Valve Co., Chicago, Ill.
American Steam Gauge and Valve Co., Boston, Mass.
American Steam Gauge and Valve Co., Chicago, Ill.
Ashton Valve Co., New York, N. Y.
Crosby Steam Gauge and Valve Co., NewYork, N. Y.
The John Davis Co., Chicago, Ill.
The Lunkenheimer Co., Cincinnati, O.
Mason Regulator Co., Boston, Mass.
Shaeffer & Budenberg, Brooklyn, N. Y. (See ad.)

Refrigerating Machinery.

Vilter Mfg. Co., Milwaukee, Wis.
Fred. W. Wolf Co., Chicago, Ill. (See ad.)
York Mfg. Co., Chicago, Ill.

Rubber Goods.

Boston Belting Co., Boston, Mass.
Boston Woven Hose and Rubber Co., Boston, Mass.
Diamond Rubber Co., Chicago, Ill.
Gutta Percha and Rubber Mfg. Co., NewYork. N. Y.
Morgan & Wright, Chicago, Ill.
Revere Rubber Co., Boston, Mass.

Scales.

Borden & Selleck Co., Chicago, Ill.
Buffalo Scale Co., Buffalo, N. Y.
Chicago Scale Co., Chicago, Ill.
Fairbanks, Morse & Co., Chicago, Ill.
Howe Scale Co., Chicago, Ill.

Safety Water Columns.

Pittsburgh Gage and Supply Co., Pittsburgh, Pa.
Reliance Gage Column Co., Cleveland, O.
Williams Gauge Co., W. Pittsburgh, Pa.
The Wright Mfg. Co., Cleveland, O.

Shafting, Pulleys, Hangers, Etc.

Advance Packing and Supply Co., Chicago, Ill.
The A. & F. Brown Co., New York, N. Y.
H. W. Caldwell & Son Co., Chicago, Ill.
Christiana Mach. Co., Christiana, Pa.
Dodge Mfg. Co., Mishawaka, Ind. (See ad.)
Jeffrey Mfg. Co., Columbus, O. (See ad.)
W. A. Jones Foundry and Mach. Co., Chicago, Ill.
Link-Belt Mfg. Co., Chicago, Ill.
A. Plamondon Mfg. Co., Chicago, Ill.
Reeves Pulley & Co., Chicago, Ill.
The Aultman Co., Canton, O.
Rockwood Mfg. Co., Indianapolis, Ind.
Henry Roos Foundry Co., Chicago, Ill.
P. M. Walton, Philadelphia, Pa.

Slicer Boxes, Knives and Files.

American Construction Supply Co., New York, N. Y. (See ad.)
Henry Disston & Sons, Philadelphia, Pa.
Wilh. Koellmann, Barmen, Gy. (See ad.)
C. W. Stoecker, Graefrath, Gy. (See ad.)
Aug. Paschen, Koethen, Gy.

Smoke Stacks.

Coatesville Boiler Works, Coatesville, Pa.

Steam Engines: (See also Corliss Engines.)

American Engine Co., Boundbrook, N. Y.
Ball Engine Co., Erie, Pa.
Buffalo Forge Co., Buffalo, N. Y.
C. H. Brown & Co., Fitchburg, Mass.
Erie City Iron Works, Chicago, Ill.
Fitchburg Steam Engine Co., Fitchburg, Mass.
Frick Company, Waynesboro, Pa.
The J. & E. Greenwald Co., Cincinnati, O,
A. L. Ide & Sons, Springfield, Ill.
Jas. Leffel & Co., Springfield, O.
McIntosh, Seymour & Co., Auborn, N. Y.
New Britain Mach. Co., New Britain, Conn.
John T. Noye Mfg. Co., Buffalo, N. Y.
Reeves Machine Co., Trenton, N. J.
Russell Engine Co., Masillon, O.
Skinner Engine Co., Erie, Pa.
SouthwerkFoundry andMach.Co.,Philadelphia
B. F. Sturtevant Co., Boston, Mass.
The William Tod Co., Youngstown, O.
Watertown Engine Co., Watertown, N. Y.

Steam and Oil Separators.

Austin Separator Co., Austin, Mich.
The Baum Separator Co., Reading, Pa.
The John Davis Co., Chicago, Ill.
Direct Separator Co., Syracuse, N. Y.
A. A. Griffing Iron Co., Philadelphia, Pa.
The Goubert Mfg. Co., New York, N. Y.
Harrison Safety Boiler Wks., Philadelphia, Pa.
The Hoppes Mfg. Co., Springfield, O.
Keystone Engine and Machine Works, Philadelphia, Pa.
Ross Valve Co., Troy, N. Y.
The Standard Steam Specialty Co., New York.
Warren, Webster & Co., Camden, N. J.

Steam Engine Indicators, Gauges, Etc.

American Steam Gauge and Valve Co., Boston, Mass.
Ashcroft Mfg. Co., Boston, Mass.
Crosby Steam Gauge and Valve Co., Boston, Mass.
Hohmann & Maurer Mfg. Co., Rochester, N. Y. (See ad.)
The Lunkenheimer Co., Cincinnati, O.
Jas. L. Robertson & Sons, New York, N. Y.
Schaeffer & Budenberg, Chicago, Ill. (See ad.)

Steam Injectors.

American Injector Co., Detroit, Mich.
The Hayden & Derby Mfg. Co., New York, N. Y.
The Lunkenheimer Co., Cincinnati, O.
Penberthy Injector Co., Detroit, Mich.
Schaeffer & Budenberg, Brooklyn, N. Y. (See ad.)
L. Schutte & Co., Philadelphia, Pa.
Sherwood Mfg. Co., Buffalo, N. Y.

Steam Pressure Regulators.

The Bristol Co., Waterbury, Conn.
Crosby Steam Gage and Valve Co., New York, N. Y.
The Lunkenheimer Co., Cincinnati, O.
The Mason Regulator Co., Boston, Mass.
Schaeffer & Budenberg, Brooklyn, N. Y. (See ad.)

Steam Traps.

Albany Steam Trap Co., Albany, N. Y.
Chas. Bond, Philadelphia, Pa.
Eureka Iron Co., Chicago, Ill.
A. A. Griffing Iron Co., Philadelphia, Pa.
William S. Haines Co., Philadelphia, Pa. (See ad.)
Helios-Upton Co., Peabody, Mass.
Schaeffer & Budenberg, Brooklyn, N. Y.
L. Schutte & Co., Philadelphia, Pa.
B. F. Sturtevant Co., Boston, Mass.
Watson & McDaniel Co., Philadelphia, Pa.
The Wright Mfg. Co., Cleveland, O.

Stokers.

The American Stoker Co., New York, N. Y.
McClave Brooks & Co., Scranton, Pa.
Playfurd Stoker Co., Cleveland, O.
The Under Feed Stoker Co., Chicago, Ill.
The Williamson Mfg. Co., Bridgeport, Con.

Structural Iron and Steel.

American Bridge Co., New York, N. Y.
J. B. & J. M. Cornell, New York, N. Y.
Samuel J. Creswell Iron Works, Philadelphia, Pa.
Duisdicker Foundry & Mfg. Co., Pekin, Ill.
Koken Iron Works, St. Louis, Mo.
Milliken Brothers, New York, N. Y.
Phoenix Iron Co., Philadelphia, Pa.
John A. Roebling's Sons Co., Trenton, N. J.
Riter-Conley Mfg. Co., Pittsburgh, Pa.

Sugar Shakers and Screens.

J. B. & J. M. Cornell, New York, N. Y.
Robt. Deely & Co., New York, N. Y.
Link-Belt Machinery Co., Chicago, Ill. (See ad.)
P. M. Walton, Philadelphia, Pa.

Syrup Testers, Etc.

The Bristol Co., Waterbury, Conn.
Eimer & Amend, New York, N. Y. (See ad.)
Hohmann & Maurer Mfg. Co., Rochester, N. Y. (See ad.)

Thermometers, Eye Glasses, Etc.

The Bristol Mfg. Co., Waterbury, Conn.
Crosby Steam Gauge and Valve Co., New York, N. Y.
Eimer & Amend, New York, N. Y. (See ad.)
Hohmann & Maurer Mfg. Co., Rochester, N. Y. (See. ad.)
Richards & Co., Ltd., Chicago, Ill. (See ad.)
L. S. Sargent & Co., Chicago, Ill.
Schaeffer & Budenberg, Brooklyn, N. Y. (See ad.)

Tanks, Sugar Cars, Etc.

The Atlantic Works, East Boston, Mass.
W. H. Caldwell & Sons Co., Chicago, Ill. (See ad.)
J. B. & J. M. Cornell, New York, N. Y. (See ad.)
Ford Bros. & Co., Philadelphia, Pa.
Lacy Mfg. Co., Los Angeles, Cal.
R. S. Newbold & Son Co., Norristown, Pa.
Philadelphia Coppersmithing Co., Philadelphia, Pa. (See ad.)
Wm. Toepfer & Sons, Milwaukee, Wis.
John Turl's Sons, New York, N. Y.
Otto Zobler Copper & Iron Works, Chicago.

Vacuum Pans and Multiple Effects.

Baeuerle & Morris, Philadelphia, Pa.
J. B. & J. M. Cornell, New York, N. Y.
Ford Bros. & Co., Philadelphia, Pa.
Geo. P. Harris & Bro., Chicago, Ill.
Haubtman & Loeb Co., Ltd., New Orleans, La.
Krajewski-Pesant Co., New York, N. Y.
H. W. Lafferty, Philadelphia, Pa. (See ad.)
Henry G. Morris, Philadelphia, Pa.
Jos. Oat & Sons, Philadelphia, Pa.
Jas. Reilly Repair and Supply Co., New York, N. Y.
D. R. Sperry & Co., Batavia, Ill.

The Sugar Apparatus Mfg. Co., Philadelphia, Pa. (See ad.)

Frank Trenkhorst, Chicago, Ill.

Wheeler Condenser and Eng. Co., New York, N. Y.

R. D. Wood & Co., Philadelphia, Pa.

Otto Zobler Copper and Iron Works, Chicago, Ill.

Vacuum and Pressure Gauges; Hydraulic Gauges.

American Steam Gauge and Valve Co., Boston, Mass.

Ashcroft Mfg. Co., Boston, Mass.

Crosby Steam Gauge and Valve Co., Boston, Mass.

Hohmann & Maurer Mfg. Co., Rochester. N. Y. (See ad.)

The Lunkenheimer Co., Cincinnati, O.

Jas. L. Kobertson & Sons, New York, N. Y.

Schaeffer & Budenberg, Brooklyn, N. Y. (See ad.)

Water Meters for Hot and Cold Water.

Ashcroft Mfg. Co., Boston, Mass.

The Bristol Co., Waterbury, Conn.

Hohmann & Maurer Mfg. Co. Rochester, N. Y. (See ad.)

Schaeffer & Budenberg, Brooklyn, N. Y. (See ad.)

Water Purifying Apparatus and Materials.

Dearborn Drug and Chemical Co., Chicago, Ill.

Industrial Water Co., New York, N. Y.

Keystone Chem. Mfg. Co., Camden, N. J.

National Steam Economizer Co., Springfield, O.

J. H. Parsons Chem. Co., Chicago, Ill.

Wm. B. Scaife & Sons, Pittsburgh, Pa.

Scalesolvent Co., New York, N. Y.

Whistles.

The Lunkenheimer Co., Cincinnati, O.

Schaeffer & Budenberg, Brooklyn, N. Y. (See ad.)

Wooden Tubs and Tanks.

W. E. Caldwell Co., Louisville, Ky.

John M. Smith & Sons, Philadelphia, Pa.

DIRECTORY—
MANUFACTURERS OF BEET FARMING TOOLS AND MACHINERY.

S. L. Allen & Co., Philadelphia, Pa. (See ad.)

Allison, Neff & Co., San Francisco, Cal.

Ames Plow Co., Boston, Mass.

Ashtabula Tool Co., Ashtabula, O. (See ad.)

Bateman Mfg. Co., Greenloch, N. Y.

E. Bement Sons, Lansing, Mich.

N. W. Barnard & Co., Chicago, Ill.

The Bucher Gibbs Plow Co., Canton, O.

Deere Implement Co., San Francisco, Cal.

Deere & Mansur, Moline, Ill.

Disc Plow Co., New Orleans, La.

Eastern Moline Plow Co., Indianapolis, Ind.

Empire Mfg. Co., Sterling, Ill.

J. A. Everitt, Indianapolis, Ind.

Farmers' Handy Wagon Co., Saginaw, Mich.

Fischer & Lewis, Detroit, Mich. (See ad.)

Yale Mfg. Co., Albion, Mich.

A. W. Genung & Son, Madison, Ohio.

D. J. Hallock & Sons, York, Pa.

Hapgood Plow Co., Alton, Ill.

Hooker & Co., San Francisco, Cal.

Jewell Bros., Platte Centre, Neb.

Mansur & Tebbetts Implement Co., New Orleans, La.

Milne Mfg. Co., Monmouth, Ill.

Moline Plow Co., Moline, Ill.

Morrison Mfg. Co., Fort Madison, Ia.

Mohr Hardware Co., West Bay City, Mich.

Duane, N. Nash, Chicago, Ill.

Ohio Cultivator Co., Bellevue, O. (See ad.)

Shuart Grader Co., Oberlin, O.

D. B. Smith & Co., Utica, N. Y.

Studebaker Gross Mfg. Co., South Bend, Ind.

Superior Drill Co., Springfield, O.

Geo. E. Tuffley & Co., Canton, O.

Withington & Cooley Mfg. Co., Jackson, Mich.

DIRECTORY—PUBLICATIONS.

NAME.		PUBLISHER.	SUBSCRIPTION PRICE.
The Beet Sugar Gazette....	**Monthly**	**The Beet Sugar Gazette Co., Chicago, Ill.** (See ad.)..................	**$2.00 per year**
The Michigan Sugar Beet ...	Weekly..	The Michigan S. B., Bay City, Mich............	$1.00 per year
The Louisiana Planter and Sugar Manufacturer.......	Weekly..	The Lousiana P. and S. M. Co., New Orleans, La..	$3.00 per year
The Sugar Beet	Monthly.	Henry Carey Baird & Co., Philadelphia, Pa.......	$1.00 per year
The Sugar Planters Journal	**Weekly.**	**The Sugar Planters Journal, New Orleans, La.** (See ad.)..............	**$2.00 per year**
Weekly Statistical Sugar Trade Journal.	**Weekly.**	**Willett & Gray, New York, N. Y.** (See ad.)........	**$15.00 per year**
The Orange Judd Farmer ...	Weekly..	Orange Judd Farmer, Chicago, Ill...............	$1.00 per year
Die Deutsche Zucker-Industrie	Weekly..	Die Deutsche Zucker-Ind., Berlin, Gy............	M. 24.00 per year
Centralblatt für die Zucker-Industrie	Weekly..	Centralblatt f. d. Z.-Ind., Magdeburg, Gy........	$4.50 per year
Blätter für Zuckerrübenbau..	Semi-Monthly.	Blätter f. Zuckerrübenbau, Berlin, Gy............	M. 5.00 per year
Wochenschrift des Centralvereines für Rübenzucker-Industrie.................	....	Centralverein f. R.-Z.-I., Vienna, Austria........	K. 24.00 per year
Journal des Fabricants de Sucre....................	Weekly..	Journal des F. d. S., Paris, France................	Frs. 30.00 per year
La Sucrerie Belge	Semi-Monthly.	La Sucrerie Belge, Brussels, Belgium..........	$3.00 per year
Sugar......................	Monthly.	Cordingley & Co., London, Eng.................	7s 6d per year
Fühling's Landwirthschaftliche Zeitung.............	Semi-Monthly.	Gebr. Junghans, Leipzig, Germany....	M. 12.00 per year
The American Sugar Industry, by Herb. Myrick		Orange Judd Farmer.....	$1.50 per copy
Beet Sugar Analysis, by E. S. Pfeiffer................. ..	....	E.C. Hamilton, Chino, Cal.	$2.50 per copy
Handbook for Chemists, by G. L. Spencer	....	John Wiley & Sons, New York, N. Y.............	$3.00 per copy
Sugar Beet Seed, by Lewis S. Ware............... ...	....	Henry Carey Baird & Co., Philadelphia, Pa.......	$2.00 per copy
Stammer's Lehrbuch der Zucker-Fabrikation	....	Friedrich Vieweg & Sohn, Brunswick, Gy.	M. 45.00 per copy
Stammer's Wegweiser in den Zuckerfabriken......... ..	....	Friedrich Vieweg & Sohn, Brunswick, Gy.........	M. 6.00 per copy
Stohmann's Handbuch der Zuckerfabrikation.........	....	Paul Parey, Berlin	M. 18.00 per copy
Die Krankheiten der Zuckerrübe, by A. Stift..........	....	Centralverein für Rübenzucker-Industrie, Vienna, Austria................	K. 4.50 per year

DIRECTORY—MANUFACTURERS AND DEALERS IN FERTILIZERS AND CHEMICALS.

NAME.	ADDRESS.	SPECIALTY.
Americ. Agric. Chemic. Co......	New York, N. Y...	Fertilizers.
Armour Fertilizer Works.....	**Chicago ....**	**Armour's Fertilizers** (See ad.)
Balfour, Williamson & Co.......	New York, N. Y., 27 William St...	Nitrate of Soda.
Boutell Brothers Co	Bay City, Mich....	Fish Fertilizer.
Calif. Chemical Works.........	San Francisco, Cal.	Chemicals.
Crocker Fertilizer & Chemical Co.	Buffalo, N. Y......	Crocker's Special Sugar Beet Fertilizer.
Darling & Co.	**Chicago, Ill.......**	**Fertilizers.**
Northwestern Fertilizer Co. ..	**Chicago, Ill.......**	**Fertilizers.**
General Chemical Co...........	Chicago, Ill.	Chemicals.
J. L. Harrington & Co..........	Chicago, Ill.	Fertilizers.
Eimer & Amend..........	**New York ... ...**	**Laboratory Chemicals.** (See ad.)
German Kali Works	**New York........**	**Potash Salts Fertilizer.**
Heller, Hirsch & Co.	**Chicago..........**	**Fertilizers.**
The Jarecki Chemical Co.......	Sandusky, O.	Fertilizers.
Michigan Carbon Works........	Detroit, Mich......	Homestead Sugar Beet Fertilizer.
John A. Myers......	**New York, N. Y., 12 John Street..**	**Nitrate of Soda.** (See ad.)
Ohio Farmers' Fertilizer Co.....	Cleveland, O......	Fertilizers.
Walker, Stratman & Co........	Pittsburg, Pa......	Fertilizers.
J. S. & D. L. Riker	New York, N. Y....	Fertilizers.
The Roessler & Hasslacher Chemical Co....................	**New York, N. Y...**	**Chemicals.** (See ad.)
Richards & Co. Ltd.	**Chicago ....**	**Laboratory Chemicals.** (See ad.)
A. L. Sargent & Co.	**Chicago ....**	**Laboratory Chemicals.**
Schoellkopf, Hartford & Hanna Co.........................	New York.........	Chemicals.
Wing & Evans................	New York.........	Chemicals.

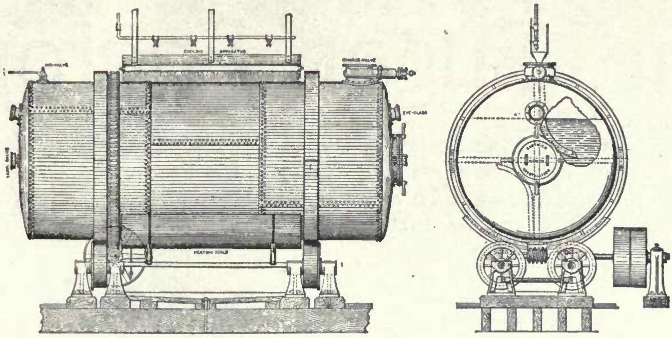
DIRECTORY—GROWERS AND DEALERS IN BEET SEED.

GROWER.	VARIETY.	SELLING AGENTS.
A. Baumeier	Kleinwanzlebener Impr.	J. W. Schaefer, New York, N. Y., (See ad.)
Dr. Bergmann	Kleinwanz. Elite	American Constr. & Supply Co., New York, N. Y. (See ad.)
Otto Breustedt	Breustedt's Elite	
	Neuere Zucht	Edw. C. Post, Dundee, Mich. (See ad.)
	Elite A	
C. Braune	Biendorf Elite Kleinwanzl.	
	Helfta Crossing	
	Biendorf Vilmorin	
	Bischofsroda Imperial	
Dippe Bros.	Elite Strains Kleinwanzl.	Aug. Roelcker & Sons, New York, N. Y. (See ad.)
Otto Hoerning	Improved Kleinwanzlebener	Edm. Starke, Caro, Mich. (See ad.)
F. Heine	Impr. Kleinwanzlebener	Frank De Connick, San Francisco, Cal.
	White Vilmorin	
A. Keilholz	Improved Kleinwanzlebener	A. Keilholz, Quedlinburg, Gy.
Klein & Soukoffsky	Kleinwanzleben Improved	
	Vilmorin améliorée	Carl Aug. Klein, Cologne, Gy.
Aug. Knoche	Knoche's Improved Richest	Aug. Knoche, Mallwitz, Gy.
	" " Kleinwanzl.	
M. Knauer	Mangold	
	Improved Kleinwanzlebener	H. Cordes, Detroit, Mich. (See ad.)
	Imperial Electoral	
Ed. Meyer	Elite Improved Kleinwanzlebener	Beet Sugar Gazette Co., Chicago, Ill. (See ad.)
T. Simon Le Grand	Le Grand's Rich Elongated	
Ladislaw Mayzell	Mayzell's Rich Elongated	Frank De Connick, San Francisco, Cal.
Otto Licht & Co.	Improved Kleinwanzlebener	
O. Schlieckmann	Specialität	
	Vilmorin blanche améliorée	O. Schlieckmann, Auleben, Gy.
	Kleinwanzlebener	
Carl Schobbert & Co.	Improv. Kleinwanzlebener	Carl Schobbert Co., Quedlinburg, Gy.
Rittergut Aderstedt	Aderstedter Original	L. Kühle, Brunswick, Gy.
G. Schreiber & Sohn	Improved Kleinwanzlebener	J. K. Armsby Co., Chicago, Ill.
	Specialty Elite	
Ad. Strandes	Improved Kleinwanzlebener	Adolph Falck, New York, N. Y. (See ad.)
Fr. Strube	Improved Kleinwanzlebener	A. Volter, Bay City, Mich.
Sugar Factory Kleinwanzleben	Original Kleinwanzlebener.	Meyer & Raapke, Omaha, Neb. (See ad.)
Vilmorin-Andrieux Co.	Original Vilmorin Improv.	
	Improv. Kleinwanzleben	
	Very Rich French	
	Vilmorin Rich Russian	Willett & Gray, New York, N. Y. (See ad.)
Ass. Maurus Deutsch	Austrian Special Kleinwanzlebener	
	Improved Vilmorin	
	Queen of the North	
Sam. Lor. Ziemann	Improved Kleinwanzlebener	
Licht	Improved Kleinwanzlebener	F. O. Boyk & Co., New York, N. Y.
	White Improved Vilmorin	

ADVERTISEMENTS.

THE ADVERTISEMENTS APPENDED ARE OF WELL-KNOWN REPRESENTATIVE FIRMS OF HIGH REPUTATION IN THE VARIOUS LINES CONNECTED WITH THE INDUSTRY.

PLEASE MENTION THIS PUBLICATION WHEN ADDRESSING ANY OF THE ADVERTISERS.



The Heintz Steam Trap...

EMBODIES THE MODERN
METHOD OF
DRIP LINE
CONTROL

Through its use you get the full efficiency of your plant at all times, with a full saving that equals, at least, the cost of the apparatus every year.

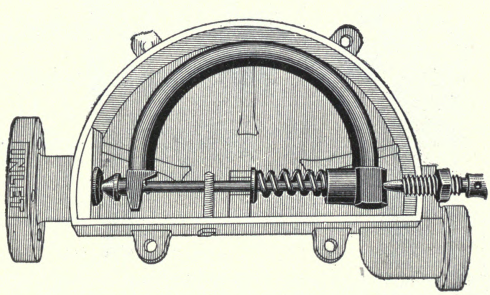
We guarantee more efficiency than the plant was designed to give and to make an even and predetermined quality of product certain.

All the necessary designs are furnished free of cost to you and we make installations subject to approval.

A postal will bring you interesting information

The
William S. Haines
Co.

18th and Hamilton
Philadelphia



HOHMANN & MAURER MFG. CO.
TRADE MARK.
H & M
ROCHESTER, N.Y.

MECHANICAL THERMOMETERS

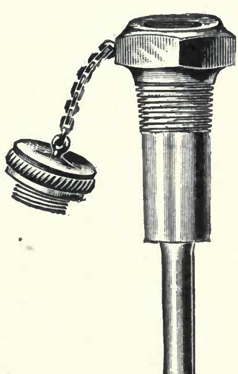
New York Office,
85 Chamber St.

London Office,
103 Hatton Garden.

SPECIALLY ADAPTED FOR BEET SUGAR MACHINERY

AS EASILY READ 10 FEET AWAY AS YOU READ THIS

Write for Catalog.

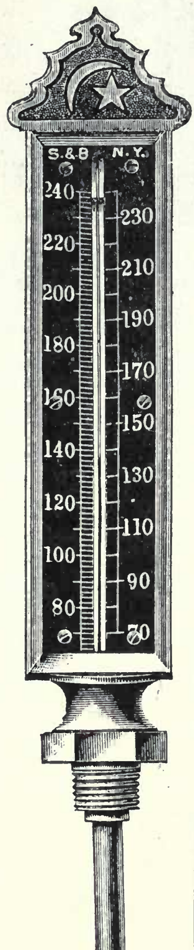


Diffusion Thermometer. Socket for Thermometer.

SCHAEFFER & BUDENBERG

MANUFACTURERS OF THE RENOWNED

CRESCENT THERMOMETERS



Especially adapted to the requirements of Sugar Makers, Chemists, Etc.

We repair all kinds of Thermometers.

We make Vacuum Pan Appliances.

We also make Vacuum Gauges, Steam Traps, Steam Separators, Chime Whistles, Fire Whistles, Recording Gauges, Recording Thermometers.

ENGINE AND BOILER APPLIANCES IN GENERAL.

SEE OUR CATALOG
WRITE FOR DISCOUNTS

WORKS AND GENERAL OFFICES:

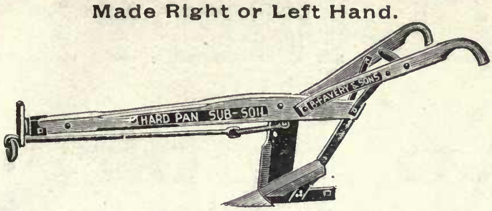
BROOKLYN, N. Y.

SALESROOMS { 66 John St., NEW YORK
15 W. Lake St., CHICAGO

NEW BEET DIGGER AND SUB-SOILER.

Made Right or Left Hand.

THE WHOLE STORY.

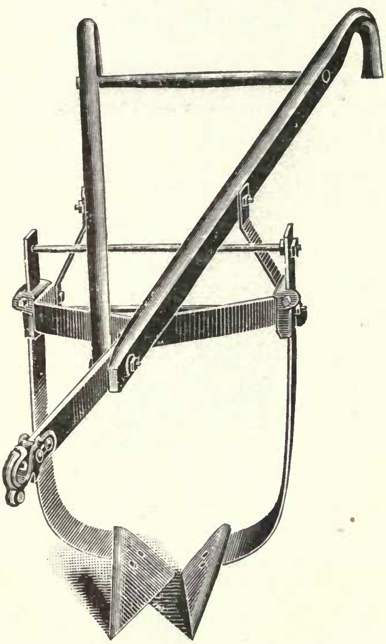


THE BIG SUCCESS.

HUNDREDS OF USERS TESTIFY LIKE THIS: MARRIOTTSVILLE, Utah, Nov. 26, '98.

The Avery Beet Digger and Sub-Soiler we bought from you is indispensable in the successful cultivation of beets. Every beet grower should have one as the ground should be sub-soiled for beets, and they can be gotten out without delay aud to the very best advantage with the same tool. The great advantage which this plow has, is that it goes below the beets and raises them up instead of cutting or breaking them off. We recommend it to be a splendid tool. (Write for prices.) Yours truly, B. AND MATTHEW DINSDALE.

B. F. AVERY & SONS, MFGS., (Estab. 1825) **LOUISVILLE, KY.**



...THE...

Ohio Beet Puller

THE BEST TOOL OUT.

When you go to buy your Puller, remember that the **Ohio** leaves the beet in its place, standing straight covered with the ground, but the tap root broken at the end, so it can be picked up with ease. The position of the blades will tell you that it is built on the right principle. Ask your dealer to order one.

FOR PARTICULARS ADDRESS:

The Ohio Cultivator Co.,

Bellevue, Ohio.

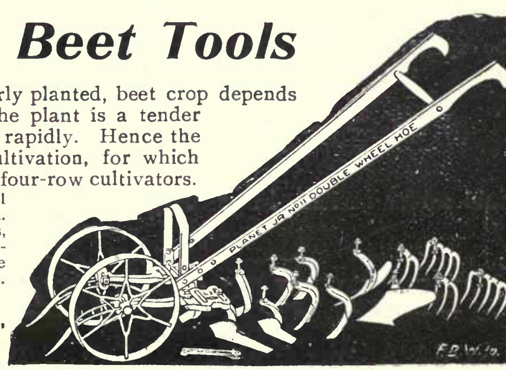
Planet Jr. Sugar Beet Tools

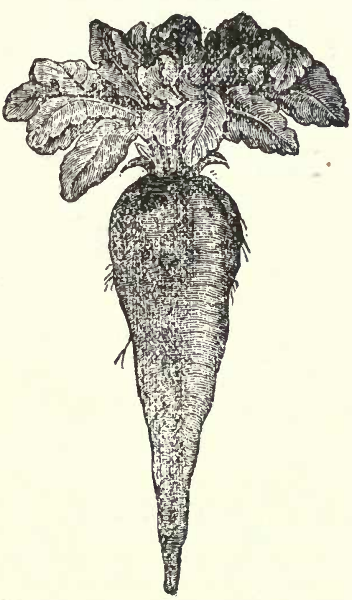
Granting that the seed is good and properly planted, beet crop depends upon nothing so much as the cultivation. The plant is a tender little fellow and a slow grower. Weeds grow rapidly. Hence the necessity of prompt, careful and thorough cultivation, for which nothing equals our "Planet Jr." one, two and four-row cultivators.

There is much more about them in our new 1901 Catalogue, which is the finest we have ever published. Tells all about our Horse Hoes, Harrows, Beet Seeders, aud reduced prices for 1901. Sixteen pages of photographic views show how "Planet Jrs." are used at home and in many foreign countries. We mail them free.

S. L. ALLEN & CO., E 710, Philadelphia, Pa.

Two Gold Medals at Paris Exposition; Highest Award.





SOMETHING TO CONSIDER:

If you are a sugar beet grower.

If you want to invest in a beet sugar factory.

IT IS THIS:

Sugar beet culture has reached its highest development in the west. All records have been surpassed in tonnage per acre, saccharine content and purity at a point on the lines of the Santa Fe Railway System.

THEN

Write to the undersigned who will be glad to furnish all the information possible regarding the number of favorable opportunities open to grower and investor. Records of experiments and campaigns, and data showing saccharine contents of beets, tonnage per acre, water supply, proximity of limestone, cost of fuel, etc., will be gladly furnished.

JAMES A. DAVIS,
Industrial Commissioner,
Atchison, Topeka & Santa Fe Railway System,
Chicago, Ill.

Beet Sugar Factories

Capital cannot find better locations for investment in the Beet Sugar Industry than in the Sugar Beet belt of Illinois, Iowa and Missouri, traversed by the

Chicago Great Western Ry.

Climate and soil adapted and farmers well qualified to make a success.

The rotation of corn and beets and the value of waste for feeding thoroughly understood.

Any efforts to establish plants for development of this industry will receive the co-operation of

W. J. REED,
Industrial Agent,
Chicago Great Western Ry.
Endicott Bldg., St. Paul, Minn.

Alphabetical Index to Advertisers.