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SUGAR

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NEW YORK

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FOREWORD

The purpose of this booklet is to acquaint the general public with the more important economic aspects of a great basic industry.

The sugar industry may be divided into three principal phases—agricultural operations, manufacture of raw sugar, and refining. Only the first two phases are given special treatment in the following pages as the refining of raw sugar is, for the most part, a distinct industry warranting separate presentation.

We are chiefly indebted to Willett & Gray's "Weekly Statistical Sugar Trade Journal" for the sugar statistics herein presented.

The accuracy of the statistics and statements contained in this booklet is not guaranteed, but they have been compiled from sources which we regard as reliable.

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THE LAND OF SUGAR

"CUBA *is essentially * * * a marvelously rich tropical island garden supplied by Nature with all the ingredients needed to maintain its fertility for many centuries to come.*"

—W. F. Johnson in "History of Cuba."

Sugar--A Basic Industry

SUGAR is a commodity in universal demand because, directly and indirectly, it is an indispensable modern food. Once a luxury available only to the favored few, sugar today forms an important part of the every-day diet of the masses. Its fundamental food value, however, is probably not generally realized. Yet dieticians tell us that one pound of sugar contains 1860 heat calories as compared with 1110 for roast beef, 1640 for wheat flour, 635 for eggs, and 325 for whole milk.

Competitive Position of Sugar

It is well known that glucose, grape sugar, maple sugar, substitute syrups, and honey serve to some degree as competitors of sugar, but generally these sweetening materials sell chiefly on their own special merits, rather than as substitutes for sugar. Even saccharin cannot be regarded as a substitute, for it has no food value. Probably more than 80% of the total quantity of sweetening materials consumed annually in the United States consists of sugar or its derivatives. On the whole, therefore, sugar is an essential commodity of every-day use, enjoying a position of substantial monopoly.

Stability of Sugar Demand

Few industries have such a constantly expanding and stable demand for their product from the consuming public. The demand for sugar expands with the growth of population and rising standards of living. The physical volume of sugar consumed is apparently little influenced by the ups and downs of the business cycle. Even in periods of abnormally high prices, we continue to buy sugar for our imperative requirements, and our total consumption either remains stationary or declines only a little under such conditions. When prices are lower, increased quantities are consumed. The sugar industry, unlike many other industries, has a fundamental advantage in the growth, stability and recurrent nature of the demand for its products.

Household and Non-Household Use

Between two-thirds and three-fourths of our annual sugar consumption is for direct household use. In recent years, the non-household use of sugar has also become important. In 1917, it was estimated that manufacturing use of sugar represented 966,000 tons, of which 350,000 tons were for confectionery, 135,000 tons for soft drinks, 100,000 tons for condensed milk, and 64,000 tons for ice cream. Since 1917, however, with the advent of prohibition, there has been a notable expansion in non-household use. For the present year, it is said that 130,000 tons of sugar will be used in the manufacture of ice cream alone, while soft drinks, confectionery, and bakery products will also show a substantially increased consumption of sugar. One needs only to consider the increased sale of confectionery, soft drinks and ice cream in recent years to realize the present and potential importance of this demand to the sugar industry.

Investment in Sugar Industry

The broad basic character of the sugar industry has caused investors to place millions of capital in the production and refining of sugar. This is true not only for those areas in which the United States is particularly interested, but also for other great producing regions. It is said that more than $1,000,000,000 has been invested by Americans in the sugar industry of Cuba alone, while the beet sugar industry of the United States represents an investment of perhaps $173,000,000, and our cane industry $33,000,000. The cane sugar industry of Porto Rico represents an investment of nearly $60,000,000; Hawaii $209,000,000; and the Philippines, $71,000,000. Only an industry of proven financial merit could have recruited such tremendous sums for its exploitation and development.

The Sugar Beet

The commercial sugar of the world is obtained from the juice of the sugar beet and the sugar cane. The sugar cane is by far the older source of sugar, and its history may be traced down to remote periods of antiquity. The extraction of sugar crystals from the juice of the beet is usually ascribed to Marggraf, a Prussian chemist who completed his first successful experiment in 1747. Supported by royal bounty, his successors improved the processes of extraction, and in 1799 at Cunern in Silesia, the first beet sugar factory in the world was constructed. The beet sugar industry was further stimulated by Napoleon, who established technical schools in 1811, and appropriated funds for the development of the industry. However, we are here less concerned with the historical than the practical economic aspects of the sugar industry.

Sugar Content

"The sugar beet," says the United States Tariff Commission, "is a highly specialized product of careful selection in breeding. In the early years of the nineteenth century, when the beet-sugar industry was established in France, the beets contained from 5 to 6 per cent sugar. American grown beets now average from 14 to 19 per cent. Until very recently American farmers have been dependent upon imported seed, chiefly from Germany and Russia." Successful production of sugar beets requires an adequate supply of cheap and suitable seed and production of seed requires a great deal of manual labor and expert scientific supervision. In seed culture as well as beet sugar production, Germany still leads the world.

Beet Cultivation

The seeds of the sugar beet are planted in the spring of the year and the beets mature in the early fall. After the young beets come through the soil, they must be carefully thinned, so as to permit growth to the proper size. During the growing season, weeds must be checked and the soil kept loose by cultivation. Beet culture is attended with the usual agricultural risks, such as lack of sunshine, drought, frost, and pests. Apparently the sugar beet must be raised in temperate regions for culture in warmer climates is not feasible because of decreased sugar yields. In the beet sugar industry, there is always the ever present possibility of reduction of production due to the cultivation of more profitable crops. Thus, if wheat prices are high and sugar prices are low, the wheat areas will be extended and the sugar beet areas will be reduced. In order to preserve the fertility of the soil in which sugar beets are grown, it is necessary to practice rotation or to use large amounts of commercial fertilizers. In some regions the beets are grown on irrigated lands.

The Sugar Cane

The sugar cane has been described as a "perennial grass, the cultivation of which is confined to the warmer regions of the earth." Disregarding the details of botanical description, it will serve our purpose to note that the stalk of the cane plant is roughly cylindrical, with joints at intervals of four to ten inches. The diameter of the stalk varies from one-half to three inches. Under some conditions, the sugar cane may attain a height of thirty feet, but one authority gives the average length of the stalk of a well grown crop as about twelve feet, and the average weight per stalk as between six and seven pounds. The percentage of sugar content varies from nine to fifteen per cent of the weight of the cane, depending upon the variety and the conditions of its growth. Usually, in the initial years of growth, the sugar content is somewhat less than in the later years.

Cane Cultivation

Sugar cane is raised by planting cuttings from the top part of the cane stalk. Around each joint of the stalk are several buds which, when the cutting is planted, throw out numerous shoots or stalks of cane. Unlike the sugar beet, it is not always necessary to replant the sugar cane each year as several crops are often cut from one planting. The first crop is known as the "plant crop" and the succeeding crop which rises from the stubble of the first planting is known as the "ratoon crop." It may be followed by several ratoon crops. Some climatic and soil conditions make necessary a highly scientific and intensive system of cultivation, but there are other semi-tropical regions so bountifully endowed with natural advantages that only slight attention is required for successful cane culture.

Beet vs. Cane

Due largely to a system of government bounties, there was a time in the history of sugar production when approximately 65% of the world's output consisted of beet sugar. For many years, however, beet sugar has been of declining importance as compared with cane sugar. In the season 1899–1900 beet sugar represented 64.9% of world production; but in 1913–14, only 47%. The output of cane sugar has doubtless been partly stimulated by the decline of beet production during the war, but even prior to the war the cane sugar industry was offering increasing and effective competition in the sugar markets of the world.

Sugar Crops of the World

Sugar is produced in many countries. It is significant that with all of the stimulus given to the sugar industry during the war, there has been no world overproduction of the commodity. In the following table the pre-war and recent crops of cane and beet sugar are presented:

Total Production

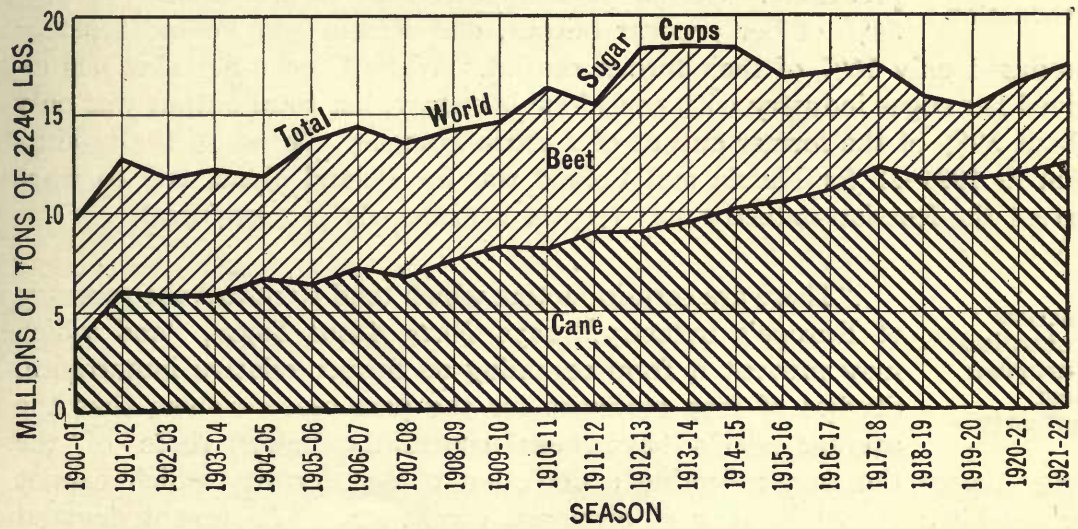
(Thousand Tons)

Season	Cane Sugar	Beet Sugar	Total
1912-13	9,290	8,918	18,208
1913-14	9,802	8,634	18,436
1914-15	10,177	8,306	18,483
1919-20	11,914	3,255	15,169
1920-21	12,001	4,676	16,677
1921-22	12,457	4,986	17,443

Deficit in World Production

The estimated world production of cane and beet sugar for the season of 1921–22 is approximately 1,000,000 tons under the figure for the crop year 1914–15. World production and consumption of sugar have not yet been restored to pre-war standards aside from any allowance for increased demand due to the growth of population. The war stimulus given to the cane industry has not resulted in any great abnormal expansion in physical production. In fact, the statistics show that it has had only a consistent and healthy growth in annual output throughout the entire period.

Cane Sugar Leads in World Production



Beet Sugar on the Continent

The great center of beet sugar production is the continent of Europe, particularly Germany. The estimated world output of beet sugar for the season 1921–22 was nearly 4,000,000 tons under that for the season of 1912–13, due chiefly to the apparent inability of the European industry to regain its pre-war standing. It seems to be the consensus of opinion that it will be many years before this restoration may be accomplished. In the following table we have presented the estimates of Willett and Gray, sugar statisticians, regarding European beet sugar production for the season 1913–14 and 1921–22 with the percentage relationship of the latter to the former crop.

European Beet Sugar Production

(Thousand Tons)

	1913-14	1921-22	% 1921-22 crop to 1913-14 crop
Germany	2,618	1,330	54%
Czecho-Slovakia	1,683	660	44%
Austria and Hungary		79	
France	717	278	39%
Belgium	229	300	131%
Holland	229	376	164%
Russia and Poland	1,688	274	16%
Sweden	137	227	165%
Denmark	146	145	100%
Italy	305	200	66%
Spain	169	135	80%

Slow Recovery of Beet Production

The table indicates that Germany, Russia, and Poland and Austria Hungary were the most important pre-war beet sugar producers. Germany's estimated 1921–22 production was only 54% of her pre-war output, and Russia and Poland together produced only 16% of their former output. While Czecho-Slovakia has revived her sugar industry with considerable energy, her total output was only about 39% of the former output of Austria Hungary. Most of the production in 1921–22 for Russia and Poland was for Poland alone, and to what extent the Russian industry may recover is extremely problematical.

Factors Retarding European Beet Industry

"There are certain factors which tend to retard the recovery of Europe's industry," says *Facts About Sugar*, "and which may prevent it from regaining its former relative importance. Studies of crop statistics for the past seasons show that the average yields have been constantly below those of the years before the war, reflecting a depletion of soil fertility which cannot be quickly restored in view of economic conditions. The urgent demand

for other food crops which command relatively higher prices tends to restrict the expansion of sugar acreage, particularly in view of the fact that Europe cannot produce sugar as cheaply as Cuba and Java. Moreover, government support is no longer extended to the European industry in the same measure as formerly." It may be expected that the European industry will continue to increase its output, but it seems apparent that for many years to come, a large part of European consumption requirements must be met from outside sources, such as Cuba and the other great cane growing regions. Because of natural advantages of location, Cuban sugars must play an important part in supplying the European market.

United States Greatest Sugar Market

The world's greatest individual market for sugar is the United States. In pre-war years, we consumed approximately one-fifth of the total world production of beet and cane sugar and in recent years our consumption has been about one-fourth. Neither high prices nor shortage have served to stop the upward movement of the consumption curve. For instance, in 1919 a year of high prices and shortage, the estimated quantity of sugar consumed in the United States was 4,067,671 tons, an appreciable increase over any prior year. There were also successive increases in 1920 and 1921, the estimated consumption of the latter year being 4,107,328 tons. Part of this increase of consumption in recent years has been due to the growth of the confectionery and soft drink business following prohibition, but part of it is the normal growth, characteristic of sugar consumption. It is estimated by Willett and Gray that over the past ninety-nine years, the average annual rate of increase in sugar consumption in the United States has been 5.216%. No other nation consumes such enormous quantities of sugar.

Sources of Our Sugar Supply

The sugar supply of the United States is obtained from our own beet sugar and cane sugar industries, and from Hawaii, the Philippines, Porto Rico and Cuba. About one-half of our sugar supply is obtained from Cuba. It is only under abnormal conditions of prices in this market that cane and beet sugar from other parts of the world find their way into the United States market in any considerable volume. This is partly but not solely due to the special tariff concessions which we give our possessions and Cuba.

The Beet Sugar Industry in the United States

The beet sugar industry has been long established in this country, the first factory having been constructed at Northampton, Mass., in 1838. To-

day the industry is mainly concentrated in California, Utah, Colorado, and Michigan. Even though favored by an early start, the industry has developed slowly. In 1895 beet sugar represented about 1% of our annual consumption. By 1911 the proportion had increased to 15.1%; and in 1921 it was about 23% of our annual consumption. In the last ten years, the industry has supplied on the average approximately 18% of our annual requirements.

For the five years preceding 1920 our production of beet sugar declined each year, but high prices and added protection gave the industry a new impetus in 1920 and the maximum crop of 969,000 tons was produced. In 1921 the output dropped to 911,000 tons and for the present season our crop will be only about 650,000 tons. This is a liberal estimate as the United States Department of Agriculture has estimated the present crop at 586,500 tons.

Handicaps of Domestic Beet Industry

Important economic and other causes have seriously restricted the expansion of the beet sugar industry in the United States. It is true that certain companies are so situated with respect to natural advantages and to consuming centers that they are able to continue operations at a profit but a large part of the industry has a hazardous and struggling existence. Production of sugar beets requires much manual labor, which is often obtained with considerable difficulty. If the American farmer finds that he can make an equal or greater profit with less laborious effort, he quickly turns to other competing crops. Before the war our industry was dependent upon Germany for its seed supply. We have made some progress in recent years in raising suitable seeds but we apparently are not able to produce as cheaply and with as great success as Germany. According to the U. S. Tariff Commission, about 20% of our production is dependent upon the protective tariff. On the whole, Yankee ingenuity has found that the domestic beet industry, in spite of the protective tariff, is less desirable for exploitation in a large way than the cane sugar industry of Cuba.

Sugar in Our Eastern Possessions

The cane sugar industries of Hawaii, the Philippines, Porto Rico, Louisiana and Texas supply an important part of our annual sugar consumption. In the pre-war years of 1912–14, these areas supplied on the average approximately 31% of our annual consumption, but in the post-war years 1919–21, the proportion declined to approximately 26%. In the following table, the percentages supplied by Hawaii and the Philippines are shown for specified years.

Per Cent United States Sugar Consumption Supplied by Hawaii and Philippines

Year	Hawaii	Philippines
1912	15.0%	3.8%
1913	13.5%	1.2%
1914	13.6%	3.2%
1919	12.7%	1.8%
1920	9.6%	2.8%
1921	11.7%	3.2%

Hawaiian Industry

Hawaii has long been an important sugar producer, but the industry did not receive any great stimulus until 1876, when Hawaiian sugar was admitted free of duty into the United States. Since annexation in 1898 the industry has expanded rapidly, the maximum production being 577,000 tons in 1914–15. For the present season the crop will be approximately 490,000 tons.

Sugar production in Hawaii is carried on under a system of intensive agriculture. "Nowhere else," says the United States Tariff Commission, "is there so effective an application of highly specialized machinery to agriculture, such extensive use of commercial fertilizers, such a comprehensive system of irrigation, such attention given to discovering and applying of the principles of scientific agriculture." Under this system Hawaii has obtained the largest sugar output per acre, but much of this production is at high unit costs and dependent upon the tariff bounty. It is said by competent authority that production in Hawaii has about reached the economic limit because nearly all of the suitable land has been planted. A few large companies control the sugar situation and have been responsible for the development of scientific cane culture.

Philippine Industry

Sugar was produced in the Philippines by rather primitive methods for many decades prior to the Spanish-American War. The modern development of the industry has been retarded by unsettled political conditions and a somewhat less favored tariff treatment than has been accorded to Hawaii. Since 1913, however, we have admitted Philippine sugar free of duty and there has been a considerable expansion in output. Over the last eleven years the maximum production of the Philippines was 332,000 tons in 1915–16. The output for the present season is estimated at 276,000 tons.

The Philippine sugar industry is now being modernized and, at some future time, it is possible that the Philippines may become a large and impor-

tant sugar producer. One of the special difficulties in the islands, however, is the lack of a trained labor supply. The natural market outlet for Philippine sugar, because of the distance from the United States, is China. Under normal conditions of prices it seems very probable that Philippine sugars will not offer effective competition in the United States market, but will continue to compete with those of Java, Formosa, and other eastern producers for the large and constantly growing Chinese trade.

Louisiana and Porto Rico

Neither Louisiana, Texas nor Porto Rico individually furnish a very large proportion of the total quantity of sugar consumed annually in the United States. We present the figures for the pre-war years 1912–14 and the post-war years 1919–21 for these regions in the following table:

Per Cent United States Sugar Consumption Supplied by Louisiana and Texas and Porto Rico

Year	Louisiana and Texas	Porto Rico
1912	7.3%	8.2%
1913	5.6%	8.8%
1914	3.8%	7.3%
1919	3.8%	7.1%
1920	2.0%	8.2%
1921	6.6%	9.1%

The Louisiana Industry

The sugar industry of Louisiana dates back to 1751, but despite this long history it now occupies a position of declining importance. Even with high tariff protection, the Louisiana industry has a somewhat precarious existence. Unlike the great low cost cane-producing regions there are wide differences in climatic and soil conditions in Louisiana, as well as in manufacturing processes. Perhaps the chief difficulty is the shortness of the growing season and the cool winters. In Cuba several crops of cane can be cut from one planting; in Louisiana there is one plant and one stubble crop and then replanting. A system of crop rotation with cow peas must be followed for the best results. For these and other reasons Louisiana is a high cost producer. During the past eleven years the maximum production of Louisiana and Texas was 322,000 tons in 1911–12, and production fell to only 108,000 tons in 1919–20. For the present season, the estimated crop is 293,000 tons. The competitive influence of Louisiana sugar in the American market is of minor significance.

The Porto Rican Industry

Sugar has been raised in Porto Rico since the early years of the sixteenth century, but there was no notable development of the industry until after American occupation. During the past eleven years the maximum output was 449,000 tons in 1916–17, and the minimum output was 308,000 tons in 1914–15. For the present crop year it is estimated that the total production will be approximately 385,000 tons.

While some Porto Rican sugar is produced at relatively low cost, the major portion is produced at a cost considerably in excess of that prevailing in Cuba and certain portions of the West Indies. Climatic and soil conditions vary widely. On the south side a large part of the product must be raised under irrigation, while on the north side the character of the soil and the excessive rainfall necessitates large expenditures for tiling and other drainage. Much of the Porto Rican land has been devoted constantly to sugar for centuries and successful production now requires extensive use of commercial fertilizers which adds much to costs. Porto Rico is thickly populated and the available tillable land is so limited that it apparently is not possible to undertake an extensive system of crop rotation in place of the application of fertilizers. In various official investigations the inefficiency of Porto Rican labor as contrasted with that of the other regions has received extensive comment. Much of the Porto Rican production is possible only because of the tariff bounty.

Gathering cane on a Cuban sugar plantation

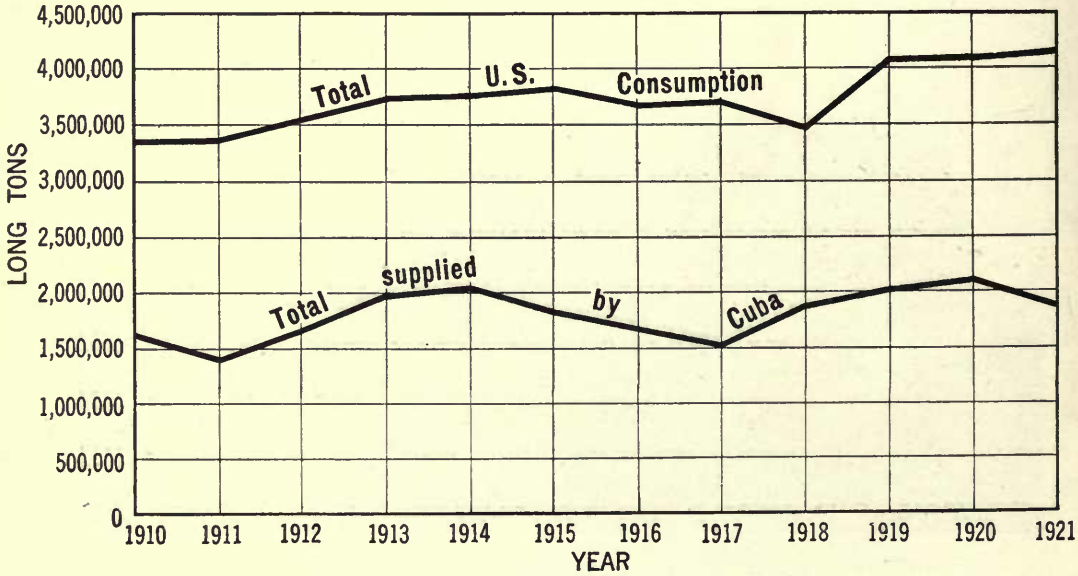
The Preferred Position of Cuban Sugar

Cuban sugar, holds a preferred position in the United States market. Over the past ten years, Cuba has supplied an average of nearly 50% of our annual consumption requirements. The average percentages of our annual consumption supplied by Cuban, domestic, and insular producers in the pre-war period 1911-13 and the post-war period 1919-21 have been as follows:

Periods	Domestic	Insular	Cuban
1911-13	22.7%	26.1%	47.6%
1919-21	22.7%	22.0%	49.5%

It is apparent that even aside from political considerations arising out of our relationship to Cuba, the American public has a very vital interest in the financing of Cuba's major industry. Indeed a large part of the splendid expansion of the Cuban industry has been due to the skill and enterprise of American capital. Why Cuba has become the world's foremost low cost producer and why the Cuban sugar industry offers excellent opportunity for sound and conservative investment will be more apparent in the subsequent paragraphs which discuss briefly the more salient features of the industry.

Total United States Sugar Consumption and Amount Supplied by Cuba



Climate of Cuba

Cuba's supremacy as a low cost sugar producer is largely due to especially favorable climatic and soil conditions, together with proximity to the greatest sugar markets of the world. The sugar cane is a plant requiring warm temperatures and much moisture during the maturing months, if the most successful results are to be attained. "The climate of Cuba," says an official study of the cane sugar industry, "is tropical and distinctly insular in characteristics of humidity, equability and high mean temperature. There are two distinct seasons, a dry season from November to April, and a hotter wet season from May to October. The average mean temperature of the island is about 77° F. Temperatures below 50° or above 90° are rare. The highest record is 100.6° and the lowest is 49.6°. The average temperature of the hottest months (July and August) is about 82° and the coldest months (December and January) about 71°. The mean relative humidity averages about 75 per cent and remains fairly uniform at all times of the year."

Rainfall in Cuba

Unlike other important cane producing regions, rainfall in Cuba, though abundant, is quite uniformly distributed throughout the island. Moreover, the major portion of the rainfall occurs during the hot summer months when it is most needed by the growing cane. "As a rule," says one authority, "the rainfall is least on the seacoast and greatest in the interior and there is little difference in rainfall between the eastern and western parts of the island. On the north coast the records kept give an average of 50 inches annually; on the south coast 45 inches; and in the interior, five miles from the shore, 60 inches." This adequate and well distributed rainfall makes unnecessary any extensive use of irrigation methods in Cuba. It is an important factor which tends to keep average costs lower than those of other cane growing regions.

Fertility of Cane Soils of Cuba

The cane soils of Cuba are in general remarkably fertile, even in areas where cane culture has been carried on for generations. The geological explanation of this marvelous fertility is that the soil of Cuba is formed of the luxurious marine and animal vegetable growth of previous geological ages. Originally, what is now Cuba was part of the ocean bottom and over this area through the ages, great quantities of decomposed organic matter were deposited. In the later geological epochs, the island was pushed up out of the sea by some great volcanic disturbances and thus this great depth of rich organic sediment was brought to the surface. Nearly two-thirds of the island is covered with soils which have been derived from organic limestone of this character, although the red and black colors of the soils suggest little of their history.

A typical Cuban plantation showing

The following comment of J. T. Crawley, a cane soil authority, on the fertility of Cuban soils is also of interest:

"The best sugar cane soils, both of Hawaii and Cuba are those in which there is a large percentage of lime. In Cuba, the lands are largely derived from limestone and therefore, this element rarely has to be supplied. Indeed I am persuaded that the great and lasting fertility of Cuban cane soil is due, in a large measure, to the lime content and to the fact that the cane trash is rarely burned off. The latter adds the organic matter necessary and in the presence of carbonate of lime, the nitrogenous material is changed to soluble nitrate which is so much needed by the plant." This natural fertility of the Cuban cane soil, combined with the plan of leaving the cane trimmings in the field makes it unnecessary for the industry to expend large sums for expensive commercial fertilizers in order to produce satisfactory crops. In other regions, such as Hawaii, Louisiana, and Porto Rico, much of the production requires their use and hence is more costly than that of Cuba.

Ratoon Crops of Cane

The lasting fertility of Cuban soils makes it possible to grow many ratoon crops of cane without the expense of replanting, and this is in part responsible for Cuba's preeminence as a low cost sugar producer. There is considerable variation in the number of ratoon crops harvested on different plantations, but seven or eight crops are common. In the more favored parts of the island, on the better plantations, the number of ratoon crops may run as high as from twelve to fifteen. Sometimes twenty or more ratoon crops are cut from a single planting. In Java, the great majority of the crop is planted annually, while in Louisiana there

cane fields separated by fire rows

is one plant crop and only one ratoon crop. In Mauritius it is not common to grow more than three ratoon crops and in Hawaii, only two ratoon crops are grown.

Agricultural Operations in Cuba

Planting of Cane in Cuba

When jungle lands on the eastern end of the island are cleared for cane plantations, the planting is a simple matter. In preparing virgin forest lands, no plowing is done; the trees are cut down and allowed to dry. The valuable timber is removed; the remainder is burned, or that part of it which is dry enough to burn; the stumps and unburned part of the trees are allowed to lie on the ground. When the land has been cleared in this manner the planting consists of making holes in the ground with a wooden pole shod with iron or with an iron bar. Cuttings are dropped into the holes and covered with earth. The cane thus planted grows from 12 to 14 months before being harvested. Notwithstanding the little care given in the planting, the cane once started, yields a profitable crop which is followed by ratoon crops for six to eight years or more with practically no cultivation. When the cane ceases to produce a paying crop of ratoons, or about eight years after the first planting on the average, the decayed stumps and parts of trees left on the ground are gathered together and burned. The land then receives its first plowing, and is planted to cane as in other countries. It is then allowed to ratoon for another eight or ten years before it becomes necessary to replant. On the older western cane lands, the initial preparation of the soil for the crop is of course more thorough than on the newer plantations in the eastern end of the island.

Cultivation of Cane

The sugar cane is planted in rows, and as it has a thick foliage, the ground is soon thoroughly shaded. This shade keeps down the weeds and aids in retaining moisture. On the newer lands, particularly, there is little expense for weeding because the dense jungle has not been favorable to the propagation of weeds, but in some parts of the island, notably on the older plantations, their elimination is accomplished at considerable expense. If the weeds become serious, they are cut down with the hoe or machete. This must be done in the early months before the foliage becomes too dense.

Harvesting of Cane

The cane begins to ripen in December and the harvesting season extends through the month of June. Some centrals however grind much later. The sugar cane is cut close to the ground with a harvesting knife called a machete. It is stripped of its leaves, and its tops, and then cut into convenient lengths of three or four feet. These cut canes are conveyed from the fields to the loading stations in ox-carts. Indeed the ox-cart has proven to be the most economical and efficient method of transporting cane in the field. It is interesting to note the survival of this primitive form of transportation in an industry which is famous for its splendid automatic mechanical devices.

Cane on the way to be made into sugar

Transportation System

Each plantation has its system of railways leading to permanent loading stations. Cane is conveyed from these stations to the sugar factory in modern cane cars, usually built of steel and having a capacity of from twenty to twenty-five tons. The modern and most generally accepted type of cane car is arranged with sides to swing out, being hinged at the top and held at the bottom or platform of the car by special clips which are easily released, from the end of the car. When the cane is delivered to the weighing stations at the factory, the actual manufacturing of raw sugar begins.

Agricultural Systems in Cuba

The cane crops of Cuba are grown under two distinct systems of agriculture: (1) the administration system; (2) the colono system. Under the administration system, the planting, cultivation, and harvesting is carried on by the sugar company directly. Only a small part of the Cuban crop is administration cane, but in Hawaii, practically all of the cane is grown under this system. It has some advantage in making possible the best development of scientific and highly specialized cane culture, where such intensive agriculture is necessary.

Colono Cane

Under the colono system the cane is planted, cultivated and harvested by independent farmers, known as colonos. It is said that about 80% of the sugar crop of Cuba is made from colono cane. This system has been aptly described in a government study entitled "The Cane Sugar Industry" as follows:

"There are several kinds or types of colonos. The independent colono grows cane on his own land. Others grow cane on the company lands, the use of which is given to them without any rental charge or for a nominal sum. Still other colonos grow cane on lands leased to them by third parties. Colonos may finance their own planting, in part or entirely, or they may secure advances of money from the company or from third parties. The method of paying for cane from colonos almost universally used in Cuba is to give the colono either a certain percentage of sugar on the weight of the cane delivered or its money equivalent. Usually liquidation is made twice monthly at the average price of sugar in Habana or other port for the current period. From 4½ to 7½ tons of sugar, or its money equivalent, are paid to the colono for every 100 tons of cane he delivers. In the more fertile or virgin soils in the Provinces of Oriente and Camaguey, where less cultivation and practically no fertilizing are necessary, the prices range from 4½ to 5½ tons of sugar per 100 tons of cane, while it reaches the maximum of 7½ and in some cases 8 tons of sugar per 100 tons of cane on the older sugar lands in the

Provinces of Santa Clara, Matanzas and Habana, where the colono has to employ more labor in the cultivation, fertilizing and sometimes the irrigation of cane, and also because two or more factories compete for this cane in these older sugar Provinces where the factories are close together."

Colono vs. Administration Cane

In considering the relative advantages and disadvantages of the colono and administration systems of cane culture, there is really only one consideration of importance from a financial standpoint and that is the question of cost. On the whole the Cuban industry has found that under prevailing conditions the colono system has important advantages. Many of the sugar companies, however, raise some administration as well as colono cane, their policies being dictated by conditions and costs.

From Juice to Crystal

Raw sugar manufacture is carried on in a factory which, with all of its appurtenances, is known as a "central." A modern sugar mill on the better plantations in Cuba represents a large investment because of the elaborate mechanical equipment required. When the cut canes reach the sugar mill they are conveyed automatically to a stand or set of corrugated rolls and are given a preliminary crushing which breaks down and shreds the cane stalks. The juice in the cane is then squeezed out by running the shredded cane through several successive stands of the rollers. There are three rollers to each stand—two large parallel rollers in the same horizontal plane and immediately above them a smaller roller parallel to the larger ones. Between the large rollers is a trough in which the juice is caught as the cane is crushed and from which it is pumped to the purifying tanks while the bagasse or fibre part of the cane is automatically conveyed to the boiler room of the factory for use as fuel.

The juice is now ready for purification and is treated with lime and heated. The heat causes the heavier and muddy impurities to sink to the bottom of the purifying tank and the lighter impurities to appear on the top as scum. Between the upper and lower layers of impurities is the clear cane juice. This clarified juice is drawn from the tank to be evaporated and the scum and other impurities are pumped to the filter presses where additional juice is recovered and added to the clarified juice already extracted.

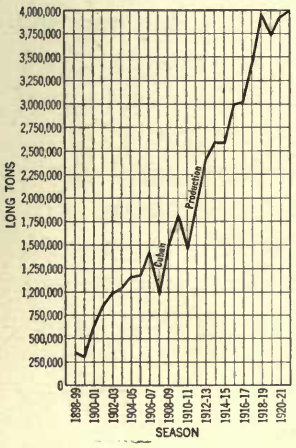
At this stage the juice is a thin mixture containing about 85% water and the next step in the process is the evaporation of this water and the reduction of the juice to the syrup point. This is accomplished in an apparatus known as the multiple evaporator. The syrup is then ready for boiling in the vacuum pan, a cylindrical vessel with a dome-like top and a conical bottom. The vacuum pan makes it possible to boil syrup in a vacuum at

low temperatures and this process is carried on until minute grains or crystals of sugar are formed. The sugar boiler adds new juice from time to time in the boiling process and the crystals are gradually built up to proper size. The crystals which are in a mixture with the residue liquor or molasses, are then ready for removal from the vacuum pan. While the mixture is warm, it is conveyed to the centrifugal machine which is essentially a brass cylinder with small perforations and is surrounded by an outer casing. The cylinders of the machines are revolved at high rates of speed and the molasses is expelled from the mixtures by centrifugal force through the perforations in the cylinders into the outer casings from which it is removed for further use or sale. If the sugar crystals are still too moist after being treated in this machine, they are dried by hot air currents before being bagged. As the sugar polarizes at about 96°, raw sugar manufactured in this manner is known as "96° centrifugal."

The centrifugal machines do not remove all of the molasses and other impurities from the sugar crystals, and hence they have a brownish appearance. This necessitates further refining before the sugar is ready for use. Cuban sugar is not refined to any considerable extent on the island, but is sold in the raw state to the refiners of the United States and other countries.

Growth of Production in Cuba

Sugar cane was introduced into Cuba in the early part of the 16th Century, but it was not until after the Spanish-American War that conditions became favorable to the expansion of the industry on a large scale. The Spanish administration of Cuba had been notoriously incompetent and the repressive features of Spanish colonial administration had fomented insurrection and rebellion. In spite of numerous handicaps, however, sugar production in Cuba reached slightly more than 1,000,000 tons in 1894 and 1895. In the latter year the rebellion began which brought on the Spanish-American War and finally led to the independence of Cuba. During this period of warfare many sugar mills, much growing cane and other properties were destroyed and the output of the industry dropped to the low level of about 212,000 tons. After the Spanish-American War the industry revived as rapidly as conditions would permit and by 1903–04 production was approximately 1,040,000 tons. The industry was given new life by the influx of American capital into the island and in succeeding years the crop increased rapidly. For the season 1911–12, the total yield was 1,912,000 tons.



The crops for the pre-war seasons 1912-15 and post-war seasons 1919-22, have been as follows:

Cuban Sugar Crops

(Thousand Tons)

Season	Crop	Season	Crop
1912-13	2,429	1919-20	3,730
1913-14	2,598	1920-21	3,936
1914-15	2,593	1921-22 (Estimate)	4,000

Today Cuba is the world's greatest sugar producer. The estimated crop for the present season will be approximately 1,500,000 tons greater than that of British India and more than double that of Java, the next largest producer. The present crop is nearly three times the German beet sugar crop of the season 1921-22. This pre-eminence of Cuba as a producer of nearly one-fourth of the world's sugar, has been in part due to the natural advantages of climate, soil and location, but full credit must also be given to the individuals—both Cuban and American—whose business sagacity and genius have directed this wonderful development.

Exports from Cuba

Normally more than three-fourths of the exports of sugar from Cuba are to the United States. In pre-war years only a small fraction of the Cuban crop found its way to other countries, but the necessities of European consumers on account of the decline of the beet industry have led to increased exports in recent years to the United Kingdom and other European countries. The United States is a great natural market for Cuban sugars and Cuba has the further advantage of preferential tariff treatment.

Cuba and the Tariff

Under the terms of the reciprocity treaty between the United States and Cuba, approved by Congress December 17, 1903, imports of Cuban products into the United States are assessed tariff duties 20% less than those imposed upon like products of other foreign countries. The treaty also provides for a reciprocal reduction of 20% to 40% on products of the United States imported into Cuba. Cuban sugar has therefore a 20% tariff preference in the United States market as compared with other foreign sugars, and products of the United States have a similar preference in Cuban markets as compared with like products of other nations. Since the present duty on 96° raw sugar is 2.206 cents per pound, Cuban sugar pays a duty under this reciprocity provision of 1.7648 cents per pound or .4412 cents less than sugars from foreign countries. Whether our tariff is revised downward or upward, as long as this treaty remains in force, Cuba will have this 20% advantage as compared with other foreign countries.

Advantage of Reciprocity to U. S.

But it must not be thought that this tariff concession given to Cuban products by the United States is without compensatory advantages. The reciprocity provision has given the American farmer and manufacturer a large and growing market in Cuba for their products. The importance of this market is partially shown by the dollar value of our imports from and exports to Cuba in recent years.

Years	Exports to Cuba	Imports from Cuba
1919	$278,391,222	$418,610,263
1920	515,208,731	721,693,880
1921	187,726,179	230,374,341

Our Political Relationship to Cuba

The people of the United States have a very direct and important interest in the prosperity of Cuba's sugar industry and there seems to be little likelihood that our tariff laws will ever be so changed as to seriously injure the chief industry of the island. It has been said that the stability of the Cuban government is conditioned upon her economic prosperity and that by virtue of the existing political relationship, we cannot avoid our obligation to facilitate particularly this prosperity. Our whole public policy toward Cuba has been built upon this principle. Prior to the enactment of the reciprocity treaty Elihu Root, then Secretary of War, said, "Aside from the moral obligation to which we committed ourselves when we drove Spain out of Cuba, and aside from the ordinary consideration of commercial advantage involved in a reciprocity treaty there are the weightiest reasons for an American public policy rounding in the same direction, for the peace of Cuba is necessary to the peace of the United States; the independence of Cuba is necessary to the safety of the United States. The same consideration which led to the war with Spain now requires that a commercial agreement be made under which Cuba can live." The late President Roosevelt in his first administration declared that our assistance in maintaining the commercial prosperity of Cuba was "demanded not only in our interests but by our honor." It would seem that the United States is morally bound to frame its tariff legislation with this fundamental principle in mind.

The Story of Three Eventful Years

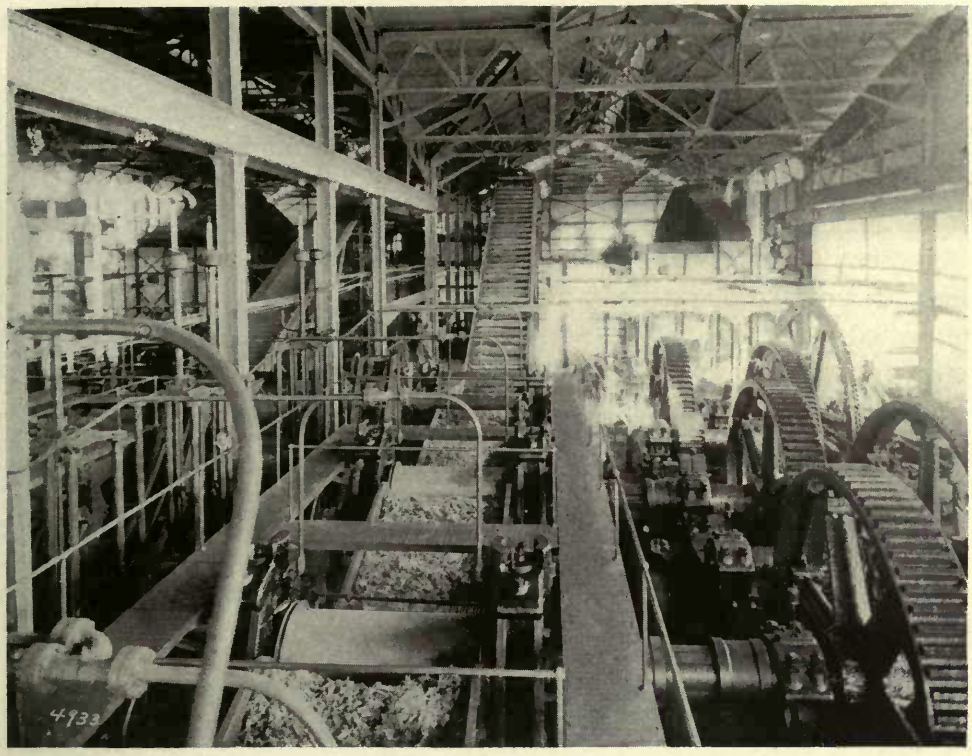
The sugar industry has recently emerged from what has been perhaps the most severe commercial depression in its history. Its troubles, however, have been similar to those experienced by many other industries in 1920 and 1921, but in the case of the sugar industry they were greatly aggravated by continuation of government control and uncertainty regarding the date of its termination. Probably the sugar industry will never again face a combination of circumstances similar to those which prevailed in 1919, 1920 and 1921,

because these conditions were largely the aftermath of government control. A brief review of the sugar market for these three years will serve to make plain the chief causes of the industry's recent troubles.

Review of Sugar Market in 1919

The year 1919 opened with the sugar situation in the United States closely controlled by the United States Sugar Equalization Board. The 1918–19 crop of Cuban sugars had been purchased and the price was fixed at 7.28 cents per pound duty paid in New York. In January, the British Royal Commission made arrangements with American refiners for refining on toll 300,000 tons of raw sugar, but it was several weeks before the Commission could secure shipping facilities to move the refined product. In February stocks of both raw and refined sugar began to accumulate and this accumulation was further stimulated by the harbor strike in New York in March. To relieve the situation the Board announced that considerable quantities of sugar had been contracted for by foreign buyers and that, in view of the general conditions, it would be wise for the public to accumulate stocks of sugar. Country-wide publicity was given to this announcement and after the long period of severe restrictions, it was only natural that consumers should hurriedly attempt to increase their stocks. In the months following this announcement, domestic consumption was at a high rate and the export movement also attained considerable volume. The shortage of sugar in this market became so serious that exports were restricted in order to supply the domestic demand. Had imports and prices not been under control of the Board at this juncture, it seems probable that considerable quantities of foreign sugar would have been marketed here and future troubles largely avoided.

As control of the sugar market was expected to terminate in December, there was active bidding for the new Cuban crop by both domestic and foreign buyers and prices moved upward. In the fall of the year, the Attorney General approved a maximum price of 18 cents for Louisiana plantation granulated and the market was further stimulated. It was officially announced that after December 1st, no licenses would be required for importation of sugars from Cuba. On account of advancing prices and the increasing shortage of supplies, Congress was urged to take the necessary action to protect the consumer. The result was that the McNary Bill was passed which empowered the administration to control the situation by such plans of purchase and distribution as were deemed necessary in the public interest. The administration, however, did not act under this law, but deemed it advisable to depend only upon the anti-profiteering and general license provisions of the Lever Act. For most practical purposes the Sugar Equalization Board ceased to function December 31, 1919, and during that month raw sugar prices rose from 7.28 cents to 12.79 cents per pound. The way had been paved for the runaway market of 1920.



Grinding the sugar cane

Review of the Sugar Market in 1920

During the spring of 1920, there continued to be a shortage of sugar and it was not until August that a real open market was established. The idea of shortage prevailed throughout the world, and domestic and foreign consumers competed with each other in securing their necessary supplies. Another factor in the situation was the successive reductions in the early estimates of the Cuban crop. Prices rose rapidly and in May the high level of 23.57 cents per pound was reached. There was no government control of the industry, but the Department of Justice instituted numerous suits under the anti-profiteering provisions of the Lever Act to prevent profiteering, hoarding and speculation, which was rampant at this particular time. It should be remembered, however, that speculation in this period was not confined to the sugar market. The abnormally high prices prevailing attracted foreign supplies from more than 50 countries and sugar was even imported from the interior of China. It became apparent during the second half of the year that the abnormally high prices could not be maintained and many speculators began to make realization sales. Meanwhile, the country was entering into the first stages of the recent business depression. Sugar prices began to fall and the decline continued for several months until by October 1st, the price of 96° centrifugal raw sugar with duty paid had reached 9 cents per pound. The sudden and drastic decline in sugar prices produced a crisis in Cuba and on October 11th, it became

necessary to declare a moratorium. In the following months prices continued to fall and the moratorium was extended.

Review of the Sugar Market in 1921

The year 1921 was unprofitable for the Cuban sugar industry for sugar prices continued to decline and stocks accumulated in large volume. In February of 1921, the Cuban Sugar Finance Commission was created to take control of the sale and shipment of the 1920-21 sugar crop. Prices, however, continued in an irregular downward movement and liquidation of stocks was very slowly accomplished. By the end of December the price of 96° centrifugal raw sugar at New York with duty paid had declined to 3.42 cents. The advantages which had been claimed for centralized control of the marketing of the 1920–21 crop by the Commission were not fully realized and to the relief of nearly every one concerned it was terminated December 31st. At this time there was on hand in Cuba a stock of approximately 1,225,000 tons of sugar and a new crop of considerable size was the immediate prospect. The sugar industry closed the year in a state of acute depression. It was prophesied that it would be at least two years before it could recover its normal position.

Modern methods and equipment are used in this Cuban sugar factory

The Return to Normalcy

The events of the past six months have proved that these prophecies were unduly pessimistic. Seldom has a great industry recovered from an acute depression with such rapidity as the sugar industry in recent months. This recovery has evidenced itself in increased prices, in the liquidation of stocks, in increased exportation of refined sugar from the United States and in a phenomenal increase in our domestic demand for sugar. The extent of this recovery in each of these respects may be briefly stated.

Recovery of Prices

The average price of 96° centrifugal raw sugar c. & f. in the period of 1909–13 was 2.704 cents. At the close of 1921 this grade of sugar was quoted at 1.84 cents c. & f. or considerably below the pre-war average. The improvement in prices, however, began in January, and in succeeding months average prices moved steadily upward and on October 16, raw sugar c. & f. was sold at 3.75 cents. This price is substantially above the average prevailing price in the pre-war period. In the following table we present the average prices per pound for raw and refined sugar in the pre-war and post-war years.

	Average Prices Raw Sugar C.&F. No Duty Paid	Average Prices Refined Sugar Wholesale
(1909-13) Average	2.704¢	4.880¢
1919 Average	6.354	9.003
1920 Average	11.337	11.390
1921 Average	3.459	6.207
1922		
Jan.	2.05	4.95
Feb	2.14	5.06
Mar.	2.31	5.28
Apr.	2.44	5.38
May	2.44	5.43
June	2.98	5.93
July	3.54	6.63
Aug.	3.56	6.94
Sept.	3.17	6.47
Oct. 1-17	3.60	6.62

Liquidation of Sugar Stocks

The Cuban sugar industry closed the year 1921 with stocks of raw sugar of the 1920–21 crop equal to approximately 1,225,000 tons. This was a tremendous carry-over, for normally Cuban stocks of raws are small at the close of the year. During the past six months this stock has been rapidly liquidated and on September 30 there were only 7,918 tons of this old sugar on hand. Not only have these stocks been liquidated, but to September 30 the industry had produced 3,971,694 tons of 1921–22 crop sugars, of which it exported to this same date 3,421,703 tons or approximately 86%. There remain on hand in Cuba after making allowance for domestic consumption, only 430,409 tons of new and old sugars. It is apparent that the Cuban industry will close the year in a very secure position with only small stocks on hand.

Revival of Sugar Exports

Part of the substantial improvement in the sugar situation in recent months has been due to the revival of our export trade in refined sugar. In the pre-war years 1911–13, our maximum sugar exports were only slightly in excess of 35,000 tons, but beginning in 1914, they expanded rapidly and the peak figure of 703,863 tons was reached in 1916. During 1917–18, exports of refined sugar fell off but in 1919 they increased to 658,664 tons. In spite of the world wide business depression of 1920 and 1921 and the depreciation of foreign exchange, our exports were around 415,000 tons of refined sugar in each of these two years. There has been an improvement of business conditions abroad and the exchange situation is now materially better for the more important consumers. Up to October 4 of the present year, it is estimated that we have exported 805,000 tons of refined sugar or more than our exports in any previous single year. Exports since January 1st of the present year have been nearly three times those of the similar period in 1921. Not only have we exported unprecedented quantities of refined sugar during the first nine months of the year, but exports of raw sugar from Cuba to England and the continent of Europe have been more than 1,000,000 tons. Considering merely the present crop of Cuban sugar, exports of raw sugar to Europe have been over three times what they were for a similar period last year. Foreign as well as domestic consumption of sugar has shown a substantial increase in recent months.

Increased Domestic Consumption

Foreign demand has been of importance as a factor in the improved sugar situation, but it has been the greatly increased domestic consumption of sugar which has been chiefly responsible for the rapid recovery of the sugar industry to normal conditions of supply and demand. According to Willett & Gray, the United States consumed 2,781,218 tons of sugar in the six months ended June 30, 1922. This is at the rate of about 5,500,000 tons per annum as compared with a consumption of 4,107,328 tons last year. While consumption in the latter part of the year is usually somewhat less than in the first six months, there is every reason to believe that this year will be a record year in the volume of sugar consumed in the United States. In this connection, Willett & Gray observe that the present rate of consumption is almost that which would normally be expected if it had increased at the same average annual rate as over the past 99 years—namely, 5.216%. This tremendous increase in consumption of sugar demonstrates the inherent stability of the industry when freed from arbitrary restrictions and control.

The Supremacy of Climate and Soil

Cuba holds a stategic position in the world's sugar industry because its natural and other advantages have combined to make it the most important low cost producer. In the production of sugar the cost of cane or beets is the most important single item of total costs. While it is difficult, if not impossible, to secure up-to-date representative itemized costs for the sugar industry in various producing regions, the following tabulation based on pre-war experience, gives a clear idea of the relative importance of various items of costs and the position of Cuba:

Average Pre-War Costs Per Ton of Beet and Cane Sugar Produced in Various Regions

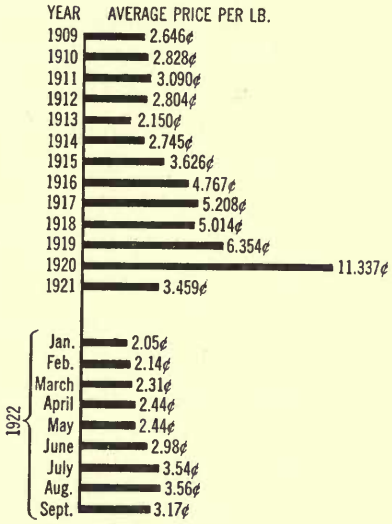
	Cost of Cane or Beets	Factory Costs	Marketing Costs	Depreci-ation	Total Costs
Domestic Beet	**$50.17**	**$23.17**	**$7.52**	**$5.10**	**$85.96**
Cuba	**20.20**	**7.89**	**5.24**	**1.42**	**34.75**
Hawaii	**35.68**	**5.85**	**13.84**	**2.78**	**58.15**
Louisiana	**66.91**	**20.44**	**2.81**	**3.08**	**93.24**
Porto Rico	**41.02**	**10.00**	**4.27**	**2.73**	**58.02**

The table indicates that the cost of domestic beets per ton of sugar produced is nearly two and one-half times the cost of cane in Cuba, while Louisiana cane costs are slightly more than three times, Porto Rico two times and Hawaii about one and three-fourths times those of Cuba. Costs today have risen in all areas as compared with pre-war experience but Cuba undoubtedly still retains its relative advantage.

Cuba's Impregnable Position

Why Cuba holds an impregnable position in the sugar industry is also clearly shown by the per pound costs of Cuban and competing sugars which have been compiled at various times by official investigators. Perhaps the most thorough investigations which have been made in recent years regarding sugar costs are those of the United States Tariff Commission made for purposes of aiding Congress in framing tariff legislation. As not all sugar producers turn out refined sugar, the Commission found it necessary to reduce all costs to a raw sugar basis for fair comparison.

Cost and Freight Prices
96° Cuba Centrifugals



These comparative costs as compiled by the Commission are presented in the following table:

Per Pound Costs Reduced to Raw Basis

(Cents per Pound)

Region	Pre-war	1916-17	1917-18	1918-19
Cuba*	1.700	2.904	3.931	4.104
Domestic Beet	3.492	3.287	4.199	6.002
Hawaii	2.898	3.853	5.339	5.196
Louisiana	4.101	3.963	5.692	9.304
Porto Rico	2.828	4.229	4.568	5.802

It is apparent therefore, that in both the pre-war and post-war periods, average Cuban costs are materially below those of other producing regions. In making this statement, however, it should be understood that the costs quoted are only average costs and that in all areas there are certain individual producers whose costs may be above or below the average quoted. The sugar business, however, is a highly competitive business and it is only the low cost producers which can most successfully withstand the rigors of this competition.

Significant Features of a Basic Industry

Sugar is an indispensable modern food. The demand for sugar is remarkably stable, being little influenced by depressions and expanding with the growth of population and rising standards of living. Between two-thirds and three-fourths of our annual consumption is in direct household use but since prohibition, non-household use is becoming increasingly important. The American people have invested more than $1,000,000,000 in the sugar industry of Cuba, a sum greatly in excess of our sugar investments in other individual regions.

The commercial sugars of the world are obtained from the juice of the sugar beet and the sugar cane. The beet is a crop of the temperate zone while cane is grown in semi-tropical and tropical regions. The beet must be planted annually and requires much manual labor. The cane as grown in Cuba ordinarily requires little attention during the months of growth and from twelve to fifteen ratoon crops may be grown from one planting. The beet industry suffers severely from the competition of other crops but in Cuba the cane industry has little competition of this character. The beet industry was built up by a system of government bounties and high tariff preferentials, but even prior to the world war it was losing its relative importance, due to the economic advantages of raising sugar cane in Cuba and

* Duties on 96° Cuban centrifugals have been as follows:
Dec. 27, 1903 to Mar. 1, 1914.....1.3480c.
Mar. 1, 1914 to May 27, 1921.....1.0048c
May 27, 1921 to Sept. 21, 1922.....1.6000c.
Sept. 21, 1922.....1.7648c.

other semi-tropical and tropical regions. The European beet industry today has not yet regained its pre-war standing and it seems to be the consensus of opinion that it will be many years before the industry will fully recover. It is this great decrease in European beet sugar production on account of the war which accounts for the fact that world production of sugar in the present season will be nearly 1,000,000 tons under the figure for the crop year 1914–15. While beet sugar production has declined, cane sugar production has shown only a normal and healthy growth.

The world's greatest individual market for sugar is the United States. We secure our supply from our own beet and cane sugar industries and from Hawaii, the Philippines, Porto Rico and Cuba. The production of beet and cane sugar in the United States and of cane sugar in our insular possessions is in a large measure dependent upon the tariff bounty, and other economic factors operate to restrict any large increase in production in these areas. For many years we have been dependent upon Cuba for about half of our annual sugar requirements.

Cuba is the world's foremost low cost sugar producer because of unusually favorable climatic and soil conditions. Sugar cane has been produced in Cuba for centuries but not until after the Spanish American War did conditions become favorable for a considerable expansion of the industry. For the present season it is estimated that Cuba will produce 4,000,000 tons as compared with 2,429,000 in the season 1912–13. Cuban sugar enjoys preferential tariff treatment in the United States market, being imported at a reduction of 20% from the regular duties. Our political relationship with Cuba, if not our economic relationship, requires that American public policies continue to be so directed as not to menace the prosperity of Cuba's major industry.

The sugar depression through which we have passed was in part due to the speculative fever which prevailed in nearly all lines of enterprise, but the chief causes of the troubles of the industry were the uncertainty regarding termination of government control and certain policies inaugurated during its continuance. The sugar industry of Cuba closed the year 1921 with an unprecedented stock of approximately 1,225,000 tons of sugar on hand. Prices were low and the industry was in a state of acute depression.

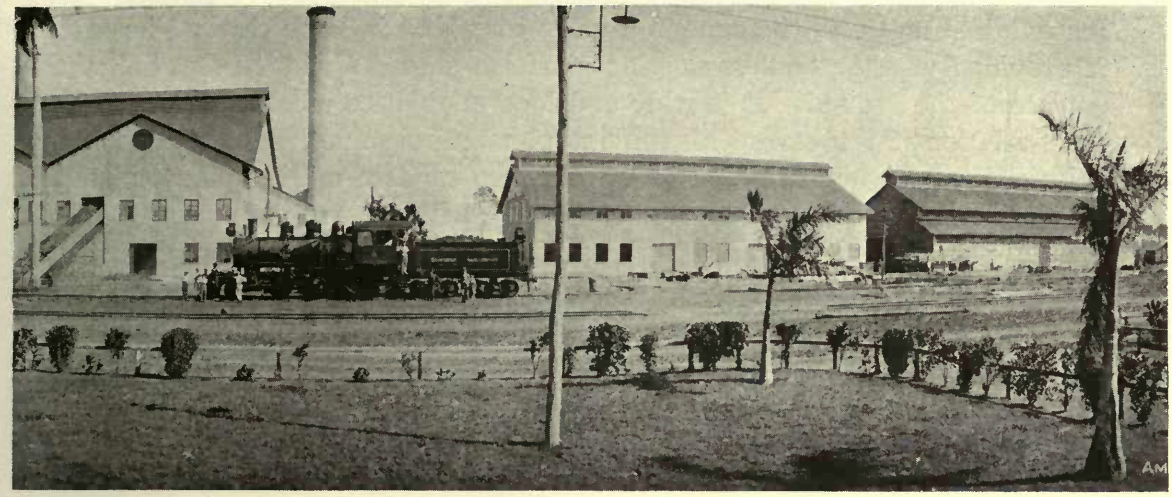
Freed from government interference and arbitrary restrictions the Cuban sugar industry has in the last six months returned to normal conditions. This return to normalcy has manifested itself in increased prices, in the liquidation of stocks, in a phenomenal increase in our domestic demand, and in an increased exportation of refined sugar from the United States. The sugar industry of Cuba is fundamentally sound. Low production costs have given it an impregnable position among the world's producers.

A typical Cuban "Central" or sugar

The Manufacture of Raw Cane Sugar

The growing of sugar cane and the manufacture of raw sugar under modern methods are pretty much the same in all parts of the tropical world. There are differences in detail which are made necessary on account of local conditions, principally cost of labor, fertility of soil, rainfall, etc. In Hawaii it has been found of great advantage to support an experimental station where the various varieties of cane best suited to the lands are developed. Cuba has not yet been forced to reach this high point of development, but very rapid strides have been made in the past fifteen years. The island has such vast expanses of land in its virgin state, that it has not been found necessary to use the intensive cultivation and fertilization of other countries.

While the manufacture of raw cane sugar in the various countries is similar in a general way, the factories differ in design and method of operation—designs accepted as the best in the Hawaiian Islands would not meet with approval in Cuba nor would those designed for Cuba be accepted in the Hawaiian Islands or any of the Far Eastern countries. In subsequent paragraphs, the factory and methods employed in Cuba in manufacturing 96° raw sugar will be briefly described with a minimum use of technical terms for the information of the layman who wants a knowledge of the process only in a general way.



factory showing loaded cane cars

Steps in Manufacture

To understand clearly the process of making sugar, it is essential to keep in mind the following steps in manufacture:

1. Weighing and keeping of complete records.
2. The extraction of the juice from the cane.
3. The purification or clarification of the juice.
4. The evaporation of about 75% of the water, reducing the juice to a syrup.
5. The concentration and crystallization of the syrup.
6. The drying of the crystals or grains in preparation for the market.
7. The bagging of the raw sugar and stacking in the warehouse

Weighing and Unloading

Weighing

The cane is received at the scales, and a complete record is kept of the weights of the cane and the field on which it is grown, as well as the farmer or colono who has raised it. Storage yards are provided close to the factory so that sufficient cane may be stored to keep the factory in operation during the night, as it is customary to operate 24 hours per day, closing down only on Sunday or a part of Sunday, for the purpose of making slight repairs and cleaning machinery.

Unloading the Cane

After passing the cane scales, the cars are placed alongside the cane carrier which feeds the mills. The system of unloading the cars of cane to the carrier differs in various centrals, depending upon local conditions. The commonly used method in Cuba has

many advantages, as the cane is usually conveyed in large cars. The carrier is provided with an endless moving platform placed about 10 feet below the surface of the ground. It is wide and long enough to receive all of the cane from a 20 or 25-ton car. This moving platform is sometimes placed horizontally or on a slight incline. If there are two tandem milling plants installed in the factory, or if it is expected that there will be two, the moving table is usually placed at right angles to the cane carrier and elevator for convenience in arranging the railway tracks. The car is placed on a tipping table, to which it is held by clamps and is tipped to an angle sufficient to allow the cane to discharge onto the moving table. After the car is emptied the table resumes its horizontal position, the empty car is removed to the storage tracks, and another loaded car is placed on the tipping table. The handling of cars from the scales to the tipping table and from there to the storage yard is usually done by means of an electric or steam winch. The moving table is driven by a steam engine or an electric motor and is so controlled that an even feed of cane is deposited on the cane carrier.

Cane Carrier or Elevator

The cane carrier is of approximately the same width as the length of the rolls employed in the crushing of the cane. It is formed by two or three strands of chain supported by rollers. Wooden slats are bolted to the chains at right angles to the direction of travel. The construction is somewhat similar to the moving table just referred to, but the carrier need not be so substantially built.

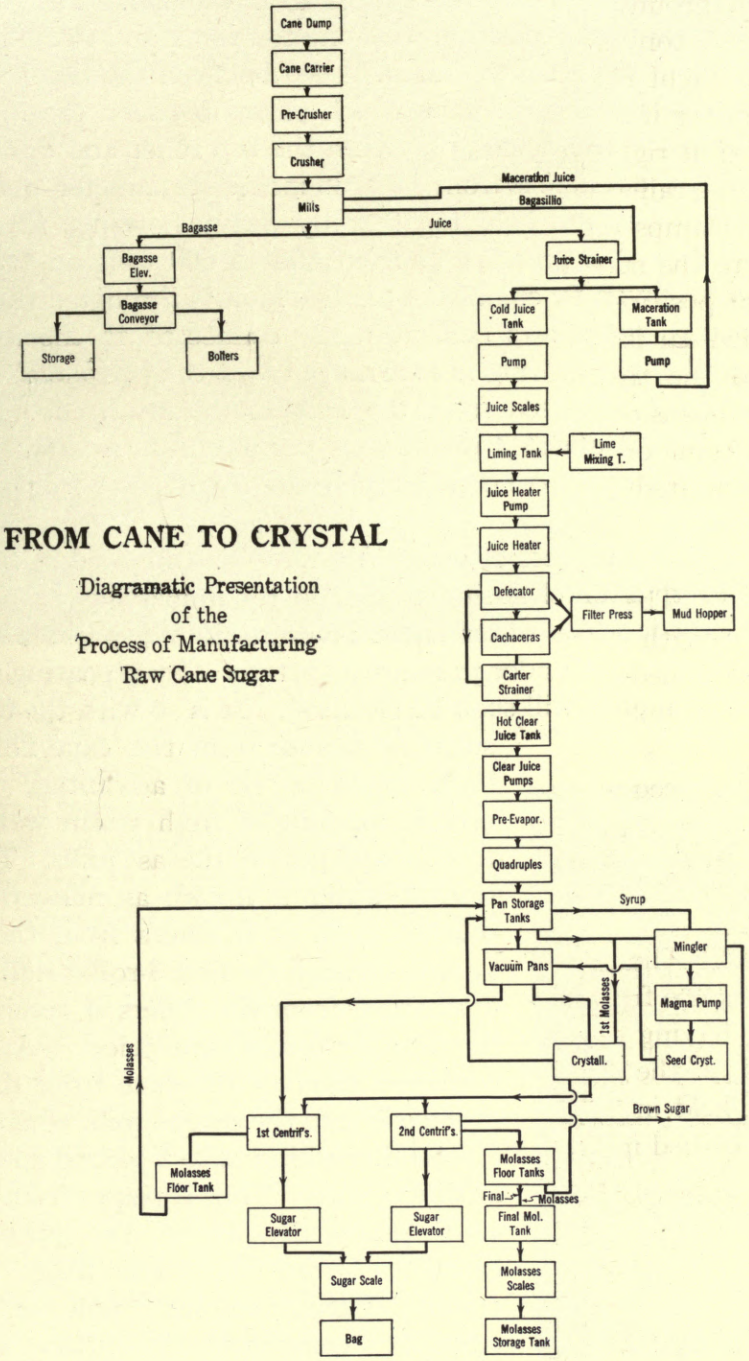
Extraction of Juice

Crushers

The modern milling or crushing plant which extracts the juice from the cane usually consists of one or two crushers, each having two rollers with interlocking or corrugated teeth or with deep grooves on the circumference of each roll. These rollers are set close together and held in place by hydraulic jacks. The cane passing through is broken and crushed into pieces and matted into an even layer.

FROM CANE TO CRYSTAL

Diagramatic Presentation
of the
Process of Manufacturing
Raw Cane Sugar

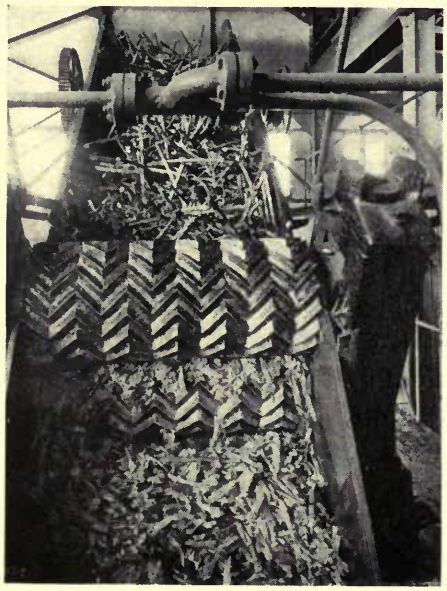


Rollers

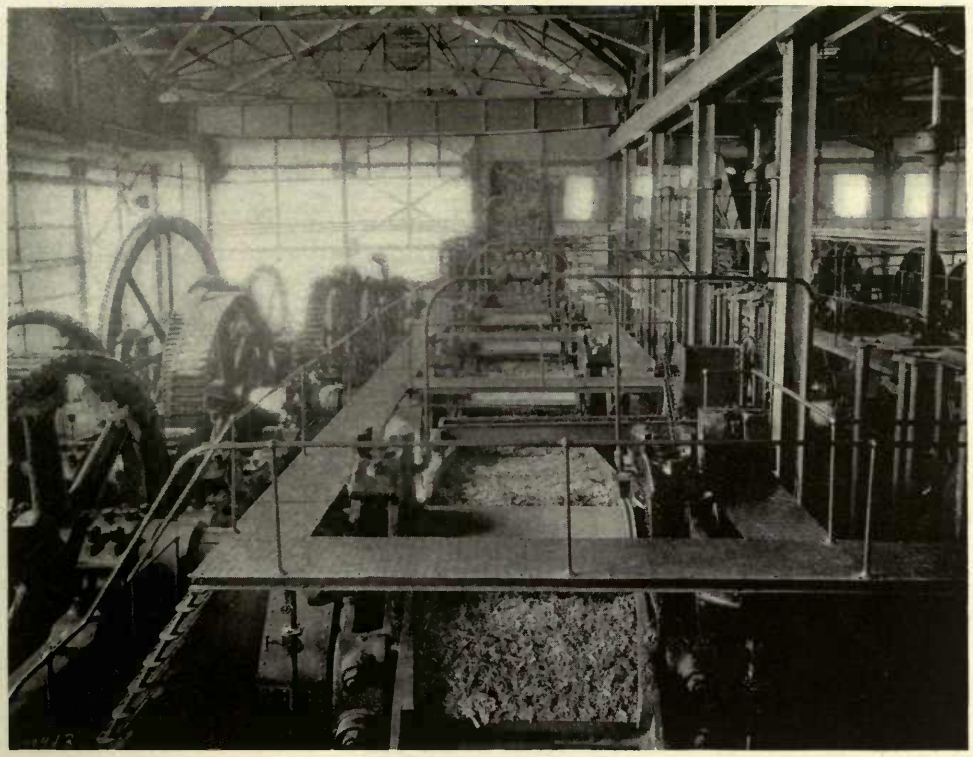
From the crusher or crushers the mat of cane is passed to the milling plant proper, which usually consists of a train of from four to six 3-roller mills set in tandem. The rollers of each mill are set in a triangular position with one top roller and two bottom rollers. A heavy bar called the returner bar is placed between the two bottom rollers for the purpose of leading the cane which passes between the top roller and first bottom roller to the opening between the top roller and discharge roller. The usual size of the rollers is from 34 to 36 inches in diameter and from 6 to 7 feet in length. They are held together by heavy housings fitted with hydraulic rams exerting a pressure of from 400 to 600 tons on the top roller. These rollers are driven by engines or electric motors through a train of double reduction gearing, the shafts being directly connected to the top rollers of each 3-roller mill. The gearing is so arranged that the peripheral speed of the rollers is gradually increased from the first to the last mill. The average speed of the rollers is about 3 revolutions per minute. A slow speed is necessary to allow the cane to be under pressure a sufficient length of time to properly extract the juice.

Masceration

The process of extraction may be compared in a simple way to that of cleansing a sponge by immersing it in water and expelling the water under pressure, immersing it a second time in water and expelling it under pressure as before. By repeating this process several times the sponge will soon be cleansed. It is so with the extraction of sugar or sucrose from the cane fibre. It has been found to be of advantage to apply a certain amount of fresh warm water between the last and next to the last mills. This application of water is known as masceration. The crushed cane as it comes from the crusher is passed through the first 3-roller mill and as it is discharged from the rollers it receives a spray of water or dilute cane juice. An automatic conveyor receives the cane from the first mill and feeds it to the second mill, where it receives a second crushing; also a second spray of water or dilute juice. Thus it passes from mill to mill until practically all of the juice has been extracted from the cane fibre. The juice coming from the last mill of the train contains comparatively little sugar, and



Crushing the cane



Milling Plant

by returning this juice to the cane before it passes into the second mill the amount of fresh water required in the maceration process is reduced. It must be remembered that all the water added to the juice must again be evaporated, and as steam is required for evaporation, it is important to use as little water as possible consistent with the percentage of sugar extracted.

The juice from the various mills is caught in a shallow metal pan and led to a trough where it is passed over a fine screen to remove all of the small pieces of cane fibre.

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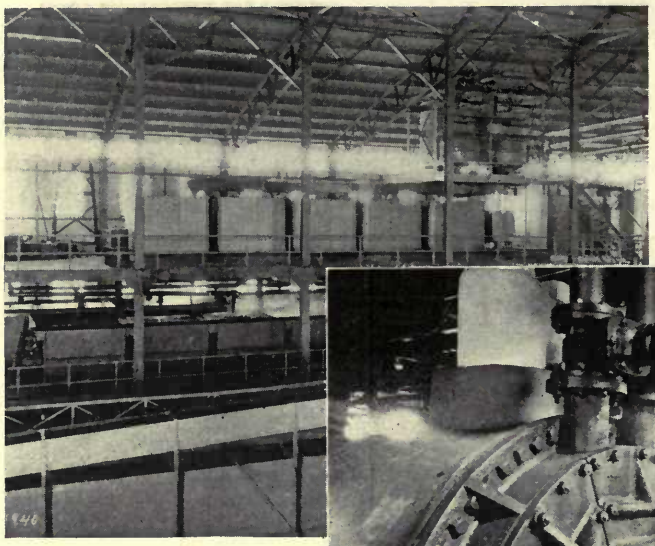
Bagasse or Waste

In well-designed modern mills, with cane carrying not over 12% fibre, more than 98% of the sugar in the cane is extracted and the remainder is left in the fibre of the cane. This fibre or woody part of the cane is known as bagasse and is comparatively dry when it leaves the last set of rollers. In the best milling work the moisture has been reduced as low as 36% of the weight of bagasse. As the fibre comes from the last mill it is conveyed directly to the furnaces underneath the boilers and in a modern raw sugar factory with cane containing 11½% fibre, no other fuel than bagasse is required for generating all of the necessary steam to operate the factory. The boiler plant is usually of large capacity and automatic conveyors are employed for the purpose of firing or stoking the boilers. The ashes from the burned bagasse are returned to the fields as fertilizer.

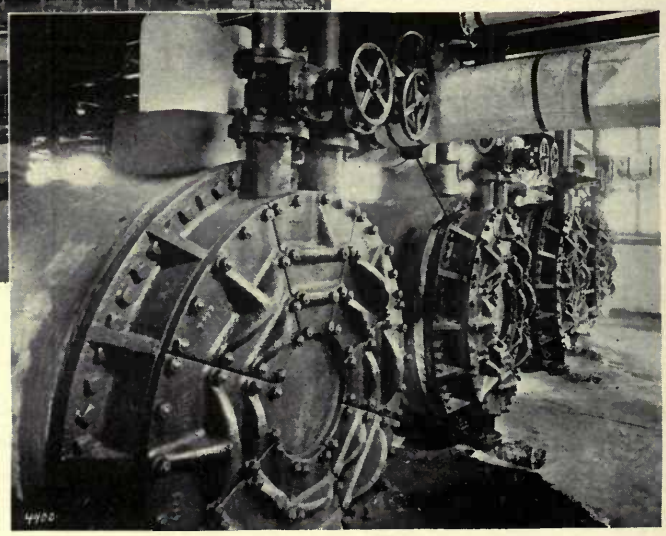
Clarification

Liming and Heating

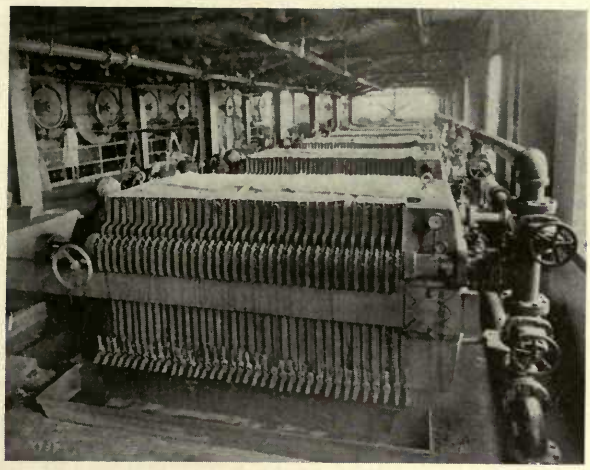
The juice as it comes from the mills contains impurities, such as dirt, small pieces of cane fibre and other foreign matter in addition to gum, salts, wax and albumen. It is necessary to remove most of these impurities. There are several methods now in use and the chemist in charge of the factory decides to a certain extent the treatment. So long as the juice is confined in the cane it does not readily ferment, except when the cane is burned before cutting. In such cases it must be worked up into sugar as soon as possible. When the juice is extracted, it rapidly undergoes a change and no time is lost in arresting this action. It is pumped into the liming tanks where it is treated with a solution of milk of lime in order to neutralize the acidity. It is then pumped into closed heaters which are usually of a cylindrical shape about 4 feet in diameter and 20 feet long, resting horizontally on frames about 2 feet above the floor. These heaters are fitted with copper tubes expanded into cast iron heads and are arranged so that the juice passes through the tubes; steam is admitted to the space between the tubes and the outer shell. The heaters are set up to permit operation in series or in parallel. When in series, the low temperature vapors form the



Juice scales, liming tanks, settling tanks and crystallizers



Heads of four cane juice heaters



Filter Presses

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heating medium in the first cell and live steam in the second cell. The juice passing from the tubes of the first cell to the tubes of the second is gradually heated to a temperature of about 210° F.

Settling

The heat causes the lime to combine rapidly with the impurities in the juice, which is discharged into open settling tanks where the insoluble solids settle to the bottom, carrying with them vegetable and other matter held in suspension. The lighter substances rise to the surface of the tanks forming a scum. The length of time allowed for settling of the juice in each tank is fixed by the chemist in charge and is usually in the neighborhood of one-half hour. The settling tanks are arranged in rows. As the juice comes from the heater, each tank is filled successively so that by the time the last of the series is being filled, the first tank has had an opportunity to settle, the clear juice has been drawn off, the mud and scum have been washed from the tank and it is ready for refilling. After settling, the clear juice is decanted from the tanks to the evaporator supply tank. In some factories it is passed through a mechanical filter which removes an additional amount of impurities. The mud and scum are drained into other tanks where lime is added. The mass is then stirred and pumped into cachaza tanks where it is again allowed to settle, the clear juice being decanted in the same manner as from the settling tanks. The final mud and other impurities are then pumped to filter presses where an additional amount of clear liquor containing a small portion of sugar is separated.

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Filter Presses

There are a number of different types of filter presses, but those generally in use at the present time rest horizontally on the floor and are made up of layers of cast iron corrugated plates covered with cotton filter cloth laid between the plates and hollow frames. When the press is dressed complete with filter cloths over the corrugated

plates alternating with hollow frames, a pressure is put on the plates and frames holding them in place. They are so arranged that the mud can be forced into the hollow frames allowing the juice to filter through the canvas to the corrugated plates where it is caught and drained to a receiving trough below. In passing through the presses under heavy pressure the sediment, scum and other impurities are caught on the canvas cloths. A certain amount of hot water is forced through the presses which takes with it a portion of the sugar remaining in the scum and mud. When the press is completely filled and the sugar recovered, the mud is then released from the press by opening the frames and removing the cloths. This mud is valuable as fertilizer and is conveyed to the fields. The clear juice from the settling tanks, the cachaza tanks and filter presses is collected in the evaporator supply tank ready to be reduced to a syrup.

Evaporation

Multiple Effects

Water boils under atmospheric pressure at sea level at a temperature of 212° F., and sugar juice a few degrees higher, according to the density. If this temperature is applied to the cane juice for a great length of time, it will have a tendency to burn and destroy the sugar, but higher temperatures can be applied to the cane juice for a short time without deterioration. The usual clarified cane juice contains in the neighborhood of 85% water and 15% of solid matter. About 75% of the water is removed in an apparatus known as an evaporator. The evaporator usually consists of four cells called a quadruple effect evaporator, or it may have five or in some cases six cells, known as quintuple or sextuple effects.

The usual type of construction is a vertical cell with the lower section forming a calandria with copper tubes inserted vertically into tube sheets, the juice passing through the tubes and the steam or vapors being held between the outer shell and the tube sheets. The juice enters the first cell and partially covers the heating tubes. Steam at about five pounds pressure is admitted to the calandria, causing the juice to boil and circulate through the tubes. The vapor liberated from the first boiling is conductedthrough vapor pipes directly into the heating calandria of the second cell and the juice from the first cell passes into the juice side of the second cell and from the second to the third and the third to the fourth. Vapors from the last cell are conducted directly to a condenser. As there is little pressure above the liquid in the first cell, it boils at about 215° to 220° F. A vacuum of approximately 5 inches is maintained in the second cell and the temperature at which the liquid will boil is reduced to about 203°, so that the vapor from the first cell is hot enough to boil the juice in the second cell. As the vapor from the second cell passes

to the heating calandria of the third cell under a vacuum of approximately 15 inches the vapors are hot enough to boil the juice in the third cell and the vapors from this cell passing to the fourth cell calandria under a vacuum of approximately 26 inches, bring the final boiling down to a temperature of about 150°. Therefore, we have had four successive boilings of juice, reducing the temperature in each cell without adding any additional live steam.

Vacuum gauges are fitted to each cell of the evaporator so that the operator may at all times know the vacuum carried. Test tubes are also fitted to the syrup side of the evaporator to permit the operator at any time to test the density. In maintaining a vacuum on this apparatus a vacuum pump is required in addition to a supply of cold water. The vapors passing to the condenser come in contact with the cold water and are condensed, the air and non-condensable gases being drawn off through the vacuum pump.

Concentration and Crystallization

Vacuum Pans

The evaporator discharges the syrup into a syrup tank from which it is pumped to the highest floor of the factory building or what is known as the vacuum pan floor. A series of tanks are

Vacuum Pans—where sugar crystals are formed

arranged to receive the syrup. Vacuum pans similar in construction to a single cell of the evaporator, with dome-like tops and conical bottoms, with heating surface arranged as a calandria, with top and bottom tube sheets connected by copper tubes or with a series of copper heating coils, are used for boiling syrups to a crystal. Leading from the top of the pan is a large vapor pipe connected with a condenser. On the conical bottom is a large valve which may be opened when the boiling is finished and the massecuite, or mixture of crystals and molasses, is dropped into a receiving tank.

Crystallization

The general principle involved in the boiling of sugar is the separation or crystallization of the sucrose contained in a solution from the impurities, and this is accomplished by evaporation. A portion of syrup is drawn into the vacuum pan as a charge, steam is turned into the heating calandria and boiling begins. After the sugar is once formed into fine crystals, these crystals attract the sucrose in the solution and continue to grow in size rather than form additional crystals. By properly timed admission of fresh concentrated juice, the crystals are provided with additional sucrose, and thus the building up continues until the crystal has reached the size desired by the sugar boiler. The crystal is pure sugar. The impurities remain in the mother liquor and are carried off as molasses. It is not possible to boil all of the syrup and molasses down to a crystal and at the same time separate the pure sucrose from the impurities; therefore, enough moisture must be left in the massecuite to permit separation of the crystals in the drying process.

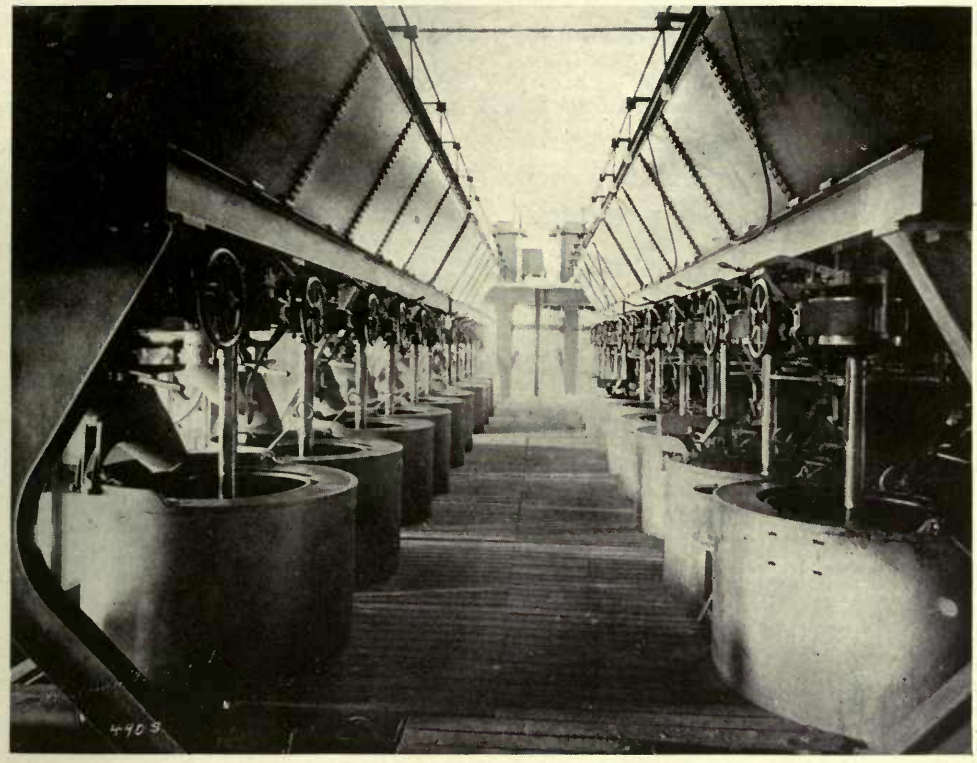
The Drying of the Sugar Crystals

Mixers

When the sugar boiler decides that the massecuite has been boiled to a proper density the whole contents of the vacuum pan are dropped into a receiving tank called a mixer. This mixer usually is held just beneath the crystallizer floor and is of V-shape. To the bottom of this mixer are attached machines used for separating the crystals from the molasses. The mixer is equipped with paddles which are revolved so as to keep the massecuite warm and prevent it from hardening before it has been dried in the centrifugals.

Centrifugal Machines

From the mixer the massecuite runs through gates into centrifugal machines for the purpose of drying. The centrifugal basket is of tub shape suspended in the center by a spindle which is held at the top in a bearing attached to the bottom of the mixing tank



Two Batteries of Centrifugal Machines Showing Mixers Above

supports. The outer part of the basket is perforated and lined with a fine screen. There is a steel curb placed around the outside of the basket to collect the molasses. A charge of massecuite weighing several hundred pounds is led into the centrifugal basket through the gates in the bottom of the mixer and the basket, which is propelled by a belt or a motor directly connected to the spindle, is then started and turns at a speed of about 1000 to 1200 revolutions per minute. The molasses percolates through the wall of sugar and fine screen and is thrown off by centrifugal force. After the basket has been revolved for a few minutes, all of the molasses has been separated from the sugar crystals. It is then brought to rest and the sugar crystals discharged through the bottom of the centrifugal into a conveyor placed horizontally below the floor.

Bagging and Storing

This conveyor takes the sugar to an elevator which deposits it into a bagging bin having a conical or V-shaped bottom.

The sugar bags are held beneath the bottom of the bin on specially arranged trucks and by opening a gate the bag is filled with sugar. In some of the later designed factories automatic weighing scales are placed beneath the bagging bins and the sugar is automatically weighed and discharged into the bags. The bags are then stacked by automatic machinery until shipped to the United States or other countries for refining.

Molasses

The Chief By-Product

The molasses which is separated from the first boiling of sugar is again treated with heat and is pumped to supply tanks on the vacuum pan floor. A part of it is drawn into the vacuum pan with the first syrups in boiling a strike of sugar. The balance of the molasses not taken in with the first syrup in the first boiling receives a second boiling in a vacuum pan similar to the No. 1 sugar but this No. 2 massecuite is discharged into large cylindrical tanks called crystallizers. These tanks have heavy steel shafts passing through them from end to end, to which are fastened scrolls or paddles and are driven by worm gearing from the outside. A strike of No. 2 massecuite received from the vacuum pan into a crystallizer is kept in motion for several days; the shaft and paddles in the crystallizer revolving at about one revolution in three minutes. As the massecuite cools sugar crystals are formed and by continuous stirring are moved about so that they come in contact with small particles of sucrose and continue to grow in size until they have absorbed the greater part of the crystallizable sugar. The massecuite is then dropped into a centrifugal mixer and is dried similarly to the No. 1 sugar. The residual molasses is pumped to a tank outside of the factory and is sold to distilleries for making alcohol or other spirits. When there is no market for alcohol, molasses is used in making of cattle food or is sometimes burned under the boilers with the bagasse. The final molasses contains potash and is sometimes burned in special furnaces for the purpose of recovering potash to be used as fertilizer.

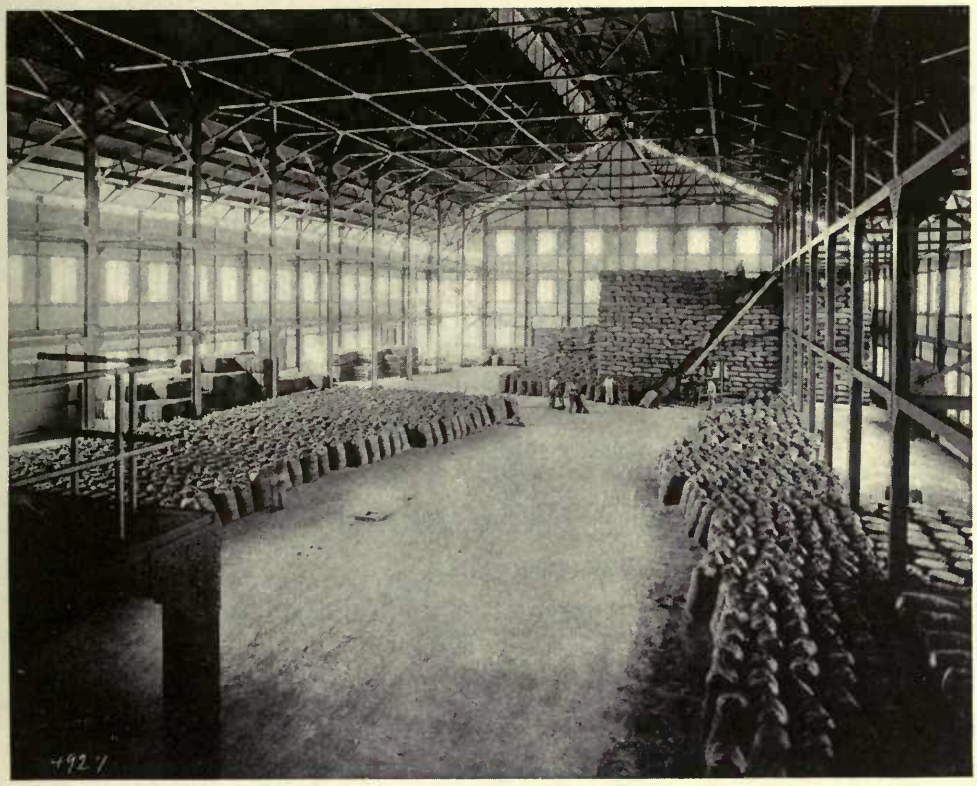
Chemical Control

Science in Manufacture

Every mill is provided with an extensive laboratory where skilled chemists are constantly engaged in sampling and analyzing the cane, raw juice, syrups, sugars and molasses. This is

one of the most important features in the production of raw sugar. There is a superintendent of manufacture who has charge of the Chemical Department and he is held responsible for the recovery of sugar from the cane. From the beginning to the end of the process of manufacture, the Chemical Department is continually on the alert, sampling and testing and analyzing to see that the loss of sucrose in the final molasses which goes to the distillery, in the bagasse which goes to the furnaces and is burned, and in the press cake which goes to the field as fertilizer, is reduced to the minimum. In the best factories the total loss in manufacture is below 2%.

It will be readily seen that in the best and latest design of raw cane sugar factories all parts of the cane are utilized, the principal by-product being the final molasses.



Sugar crystals—bagged and ready for shipment to refineries.

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