The
BEET SUGAR
Story

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Chapter Two

EARLY SUGAR HISTORY

The romantic story of sugar reaches far back into the shadowy mists of ancient times, and to view the American beet sugar industry in proper perspective it is best to take first a brief glimpse at the fascinating role sugar has played in the history of the world.

Early Sugar Cane History

Primitive man satisfied his hunger for sweets by eating honey and plants containing sugar. Sugar cane apparently was known in India and elsewhere in the Orient hundreds of years before the Christian era, and the Old Testament twice mentions it. In Jeremiah 6:20, the prophet asks, "To what purpose cometh there to me incense from Sheba, and the sweet cane from a far country?" In Isaiah 43:24, the accusation — "Thou hast bought me no sweet cane with money" — is evidence that even in Isaiah's time sugar cane was an article of commerce.

Europe discovered the art of crystallizing sugar in the fourth century, but refining in the modern sense can hardly be said to have been practiced until the fourteenth century. At first the sweet crystals were used largely for medicinal purposes, and not until the Elizabethan period did sugar become an article of household use.

Arabs became acquainted with sugar when they swept over Persia, and as they continued westward they extended the art of cane cultivation to the northern coast of Africa, and thence into Spain. Cane plantations were found by the Crusaders in Tripoli, Mesopotamia, Syria, Palestine, and Antioch, and they eventually became interested in the sugar trade, making Tyre the center of their operations. Once having acquired a taste for sugar, they were in no mood to discontinue its use when they returned to their

homes, and as a consequence a lively trade in sugar sprang up between northern Europe and the seaports of the Mediterranean.

Even before the Crusades, Venetian merchants had conducted a commerce in sugar, spices, silks and other products of the East. Ships were small, but the volume of trading was larger than might be imagined. In 1319, Tomaso Loredano, a Venetian merchant, sent a hundred thousand pounds of sugar to England to be exchanged for wool.

The passing years brought to Venice a virtual monopoly over the commerce in sugar, which her traders sought to protect and extend in every way possible. One such way offered itself in 1420 when an unnamed inventor perfected a method of refining. To gain control of the process, Venetians paid the inventor an amount equivalent to $120,000, which was ten times the cost of financing the first voyage of Columbus across the Atlantic. As the demand for sugar grew, the merchants of Venice increased prices, resulting in widespread complaint in Europe.

The Portuguese were the first to take effective action against the monopoly of the Venetians. In 1419 Prince Henry the Navigator discovered Madeira, and there the Portuguese planted cuttings of cane they had obtained from Sicily. The cane grew abundantly. When the Azores, Cape Verde Islands and Canary Islands were discovered, cane was planted there also. By 1472 cane was being cultivated on virtually all the islands along the African coast as far south as St. Thomas. Lisbon grew in power and wealth. Venice passed the peak of its glory and began to decline.

Columbus brought cane to the New World, and in a letter to Ferdinand and Isabella he expressed satisfaction at "the way a few small canes planted here have taken root." To the Spaniards, also, belongs the credit for having developed cane production on a commercial scale in the West Indies, first in San Domingo. Sugar plantations there began to prosper after a cheap supply of labor — slaves imported from Africa — became available. The success of the venture in San Domingo led to the cultivation of cane in the other islands of the West Indies and on the mainland of South America. In all these places it flourished — perhaps, indeed, it flourished too well, for it nourished the fester of slavery for more than 150 years.

Early Sugar Beet History

Cane had been grown in the tropical areas of the New World generations before sugar extracted from the beet root made its

first appearance in Europe. That is not to say, of course, that ancestors of the present sugar beet were unknown in bygone days. On the contrary, some scholars believe sugar beets were eaten by the laborers who piled up the pyramid of Cheops, Egyptian Pharaoh who lived about three thousand years before Christ.

Apparently the beet grew in wild state in parts of Asia, and at an early time it was cultivated in southern Europe as well as in Egypt. Classical writers made many references to the beet root. Hippocrates, the Greek physician, said that a beet broth had a salutary effect in treating certain ailments, and that beet leaves dipped in wine had healing properties when applied to wounds.

Plautus, Cicero, Suetonius and Columella all have something to tell about the beet. At various times it was proposed that beet juice be used as a hair tonic, for cleaning the teeth and for restoring flavor of wine that had soured.

The literature of the Middle Ages contains allusions to the beet and its importance to the diet. Yet other qualities were not passed by unnoticed. The Portuguese poet, Gil Vicente, who lived about 1500, wrote a merry couplet which may be loosely translated:

"One's head should have as much of brains
As the sweetness which the beet contains."

Early in the 1600's an observant Frenchman, Olivier de Serres, wrote: "The beet root when boiled yields a juice similar to syrup of sugar." Another century passed before extraction of sugar from the beet was demonstrated to be practical on a commercial scale. Meantime repeated efforts, all unsuccessful, were made to obtain sugar from apples, pears, corn, quinces, mulberries, plums, figs, pumpkins, watermelons and even from walnuts and chestnuts.

Beet Sugar in Europe

Events which resulted in establishment of the beet sugar industry in Europe involved, in this order, the laboratory experiments of a German chemist, the perseverance of one of his students, the backing of a Prussian king, the urgent needs of an empire at war, and the dynamic action of a French emperor.

In 1747 Andreas Marggraf, a German chemist, proved in his laboratory that the beet root stored pure sucrose and that it could be extracted in crystalline form. But no one seemed excited — probably because the process of extraction had all the earmarks

of a laboratory trick. Marggraf had sliced the beets, then dried and pulverized them. On eight ounces of the powder he poured six ounces of alcohol, and placed the mixture over a slow fire. When the liquid came to a boil, he withdrew it from the fire and filtered it into a flagon which he corked and allowed to stand for some weeks. At the end of the time, he reported, crystals had formed — crystals which had all the physical and chemical characteristics of sugar from cane.

The enthusiasm that might have been expected at the announcement of Marggraf's discovery was saved for another forty years until Franz Karl Achard, one of his pupils, planted beets on a rather extensive scale and succeeded in obtaining a substantial amount of sugar from them. He calculated that a good, low-grade sugar could be produced for six cents a pound, a figure which seemed so low that members of the French Institute investigated his claims. These learned gentlemen found that the extraction of sugar from beets on a commercial scale was wholly possible — but, they said, the cost probably would reach eighteen cents a pound.

Frederick William III, King of Prussia, interested himself in Achard's work and provided funds for the world's first beet sugar factory, which was erected at Cunern, Silesia. Operations were begun in 1802, and in relatively few years it became apparent that, with intelligent management, the project was bound to succeed. The French, meantime, had been corresponding with Achard, and sugar factories were hopefully built at Saint-Ouen and Chelles. But because the French lacked technical knowledge and practical experience, their enterprises miscarried, just as so many other beet sugar developments were to fail for the same reasons in later years. As a result of these disappointments, attention was diverted from beets to grapes, and French scientists tried to imprison crystals of grape sugar in their test-tubes. Their efforts were partly successful, and for a time grape syrup to some extent replaced cane syrup.

This determination to develop a supplementary source of sugar on the Continent of Europe was rooted in need. The French, embroiled in the Napoleonic Wars, found themselves cut off from the sugar which usually flowed to them from the West Indies, and prices mounted rapidly to more than a dollar a pound. It was a matter of national concern, just as our own sugar supplies have concerned us during periods of war.

The experiments with grapes were finally abandoned, and scientists turned back to the beet. One of them, M. Deyeaux,

pharmacist to the Emperor, successfully produced a few loaves of "perfectly crystallized sugar, very white, very sweet — enjoying, in a word, all the properties of the best cane sugar." Another was Benjamin Delessert, who erected a small factory at Passy and went about his business without the fanfare attending the activities at Saint-Ouen and Chelles. By January, 1811, he had made a quantity of well-crystallized beet sugar.

The achievement was reported to the Minister of the Interior, who in turn relayed the news to Napoleon. It needs the enthusiasm of a French writer to describe how Napoleon reacted: "Enraptured, Napoleon cried out, 'We must see this. Let us go at once.' After having seen the results for himself, the Emperor approached Delessert, and, taking off the Cross of Honor which he wore on his breast, he pinned it on Delessert. Next day the *Moniteur* announced that a great revolution in French commerce had been wrought."

On March 18, 1811, he ordered his Minister of the Interior to take "all steps" to encourage the growing of sugar beets and the erection of beet sugar factories. Significantly, he requested the Minister to advise French farmers "that the growing of beet root improves the soil, and that the residue of the fabrication furnishes an excellent food for cattle."

Seven days later Napoleon "took steps" himself, and by the stroke of a quill pen brought a new industry into being. At the Palace of the Tuileries he signed a decree that 79,000 acres of land be planted to beets as quickly as possible, and that six experimental stations be established for the instruction of farmers and landowners. Moreover, he appropriated one million francs to implement the program.

Political cartoonists of the period found in Napoleon's interest in the sugar beet a topic suited to their wit. One contemporary cartoon shows the Emperor squeezing the juice of a beet into his coffee. His son, the infant King of Rome, sits in a nearby cradle with a beet pressed to his mouth, while an acid-faced nurse tells the child: "Suce, mon cheri, suce! Ton père dit que c'est du sucre" — "Suck, dear, suck! Your father says it is sugar."

And sugar it was! — sugar that energized Napoleon's armies! The dire need for a quick-energy food gave the beet sugar industry its first big commercial push. As a result of Napoleon's various decrees 334 small beet sugar factories were erected in France in 1812 and 1813.

But the industry born of urgent necessity was shortly to experience extreme difficulties. Waterloo — June 18, 1815 —

crushed an industry as well as an Emperor. With the downfall of Napoleon, the blockade was lifted and ships from the West Indies hastened to dump their cargoes of accumulated sugar into the ports of the Continent. Prices collapsed. The newly established beet sugar factories were hit hard by the war's aftermath. Struggling with primitive processing methods and raw materials of low quality, the homeland industry was unable to withstand the effects of this wholesale dumping of cane sugar produced by slave labor in the French Colonies. One year after Waterloo, only a single beet sugar mill, at Arras, remained in operation in France.

Yet even in these desperate straits the industry had champions who refused to become despondent. A few brief years had taught them that the beet had a definite and valuable place in agriculture. Bit by bit, improvements in the processes of manufacture more than doubled the percentage of sugar extracted from a ton of beets — although it still was low by modern standards. Better beets — richer in sugar — were developed. These improvements, and the passage of laws which sought to equalize the conditions of competition between the producers of the Indies and those at home, gradually brought about a restoration of the industry in France. Louis Philippe, French ruler from 1830 to 1848, and Napoleon III, who reigned from 1852 to 1870, especially recognized the value of a home-produced sugar supply, and initiated effective government programs to encourage the beet sugar industry.

Meanwhile, the industry was becoming established in other European countries, notably Germany. A German sugar school, set up in January, 1812, drew students from all parts of continental Europe and they in turn had a profound influence in the later development of the industry throughout Europe. If the growth of the industry in Germany was slower than in France, it was nevertheless founded on a more substantial basis, possibly because the Germans were not torn by conflicting loyalties between overseas production and homeland production. The German industry, however, like that of France, suffered a severe setback by the flood of slave-produced sugar from the tropics which followed the downfall of Napoleon and the lifting of the European blockade. But as in France, persistent efforts and governmental encouragement re-established the industry.

In any event, the emancipation of slaves in the West Indies finally put the European beet sugar industry in a position in which it was able to offer more effective competition to tropical sugars. By 1854 the industry was operating on a large scale over

most of the continent, and soon thereafter European-produced beet sugar was being exported in sizeable quantities. Today, beet sugar is produced from the United Kingdom to Russia, from Finland to Italy — in every European country but Norway and Portugal. And sugar beet culture has spread to much of the rest of the world: to the Near East — Turkey, Syria, Afghanistan, Iran; to the Far East — Japan, Manchuria; to the Americas — the United States, Canada, Chile; and to other places. The importance of the beet sugar industry to the economies of several nations is recognized by national programs of encouragement and protection.

Chapter Three

THE SUGAR BEET TAKES ROOT IN AMERICA

For many years a variety of wild sugar beet has been observed growing in central California. This fact, coupled with statements in an eighteenth century manuscript of a Spanish explorer, has led to conjecture that California Indians may have developed a method of extracting sugar from the beet before Europeans did. Pedro Fages, a Spanish captain who explored parts of California between 1768 and 1772, wrote in 1775: "Those [the tribes] of the Sierras made also quantities of molasses, candy, and sugar, that is not unworthy of the fame of these people, and it is extracted from certain species of vegetables. . ."

Be that as it may, the first attempts by the white man to establish a beet sugar industry in America occurred near the East Coast rather than the West, and the industry's pioneers turned to Europe for information and for seed.

Fifty Years of Pioneering

Men of vision in the New World watched with intense interest the rebirth of the beet sugar industry in France and its development elsewhere in Europe. They saw a three-fold advantage to be gained through beet sugar production in the United States: freedom from almost complete dependence on foreign countries for sugar; benefits a new industry would bring to the young nation's economy; and the improvement in agricultural practices which beet culture would encourage. If the technical skill of the early American champions of beet sugar had matched their vision and enthusiasm, the industry would have become a permanent part of the American scene in the first half of the nineteenth century. As it was, nearly fifty years elapsed between the first known attempt

and lasting success at establishing beet sugar manufacture in the United States.

The first effort of which any comprehensive record remains was launched in 1830 by James Ronaldson of Philadelphia, first president of the Franklin Institute of that city. He interested some friends in the project, and together they organized the Beet Sugar Society of Philadelphia. In 1836 the Society sent James Pedder to Europe to make a thorough study. He shipped back six hundred pounds of beet seed, which unfortunately was planted too late in the season to produce beets good for anything but cattle feed. Mr. Pedder's glowing report of the possibilities for a beet sugar industry in the United States remains today as the principal accomplishment of the Beet Sugar Society of Philadelphia.

The next two attempts resulted in something more substantial than a report — the erection of two sugar factories.

At Northampton, Massachusetts, Edward Church and David Lee Child, who had observed beet sugar production in France, sparked the effort which produced the first beet sugar in the United States, some 1,300 pounds, in 1838. But economic difficulties beset this venture, and the factory closed its doors forever in 1841.

Meanwhile, many miles to the west, at White Pigeon, Michigan, farmers and townsfolk organized the Beet Sugar Company in 1837 and built a factory in 1838. Despite a $5,000 loan from the State of Michigan, this venture also failed — largely because of lack of technical knowledge and skill.

More than a decade passed before the logic behind the production of sugar in the temperate zone of the continental United States reasserted itself through action, this time in one of the most colorful episodes of sugar history.

In 1847 the members of a new religious movement, the Mormon Church, settled in Utah and sought to create, so far as possible, a self-sufficient community. Cut off by time and distance from the eastern states, the Mormons were forced to pay dearly for all articles they could not produce themselves. One dollar a pound was the usual price for sugar.

Thus it was with a practical zeal that John Taylor studied the beet sugar industry in France while he served there as a missionary for the Church. With Church approval, he organized the Deseret Manufacturing Company with the express purpose of establishing the industry in Utah. At a cost of $12,500, the company purchased a complete sugar manufacturing outfit, which arrived in New Orleans from France in April, 1852. The heavy

machinery was floated up the Mississippi and Missouri Rivers by boat to Fort Leavenworth, Kansas, where it was loaded into covered wagons drawn by fifty-two ox teams. From Kansas to Utah was a slow and painful journey in those days. Wagons broke down; oxen strayed; food supplies ran low. It was not until November that the party convoying the equipment arrived, hungry and cold, at its destination.

It would be pleasant to record that, after such hardships, the attempt of courageous pioneers to produce sugar in Utah was an immediate success. On the contrary, it was a distinct failure, because, as so often before and after, the promoters lacked technical information to temper their enthusiasm. The factory produced only an inedible syrup.

Even before the Mormon venture the possibility of producing sugar in the West had been investigated. A petition filed January 8, 1841, by Guadalupe Miranda and Carlos Beaubien asked that a portion of land, now included within Colorado, be granted by the governor of the province of New Mexico for the culture of sugar beets.

Colorado apparently was interested in sugar during the exciting period of the Gold Rush, for as early as 1865 Peter Magnes, a Swedish immigrant, prophesied: "If we had beet sugar factories in Colorado, I imagine Colorado farmers would produce more gold than all the mines in the mountains." His prophecy has been fulfilled over and over, but Colorado was to wait until the turn of the century to see her first sugar factory in operation.

In other states, interest ran high and then ebbed as failure overtook all fourteen sugar factories erected between 1838 and 1879 — in Maine, Massachusetts, Delaware, Michigan, Illinois, Wisconsin, Utah and California. But the American pioneering spirit is tough, and disappointment in one area seemed to spur hope and enthusiasm in another. Perseverance finally won.

Success in California, 1879

To E. H. Dyer goes the credit for establishing the beet sugar industry in the United States on a successful basis, in 1879, at Alvarado, California. The factory at Alvarado, near the east shore of San Francisco Bay, was first built in 1870, but the original company went bankrupt and the machinery was moved out. With a group of associates, Mr. Dyer took over the buildings in 1879, installed different equipment, and put the operation on a paying basis. This was the first solid demonstration in the United States

that sugar could be extracted from beets successfully and profitably. After undergoing several renovations and enlargements, this historic factory was completely rebuilt in 1936 and is still in operation.

In 1888 at Watsonville, California, Claus Spreckels built the second successfully-operated beet sugar factory which, in that year, produced 1,000 tons of beet sugar.

The successes in California renewed interest in the beet sugar industry in other states. Henry Oxnard and his three brothers were among the first to take action. They went to Europe, made a careful study of the industry there, and in 1890 built a factory at Grand Island, Nebraska. In 1891 they built two more, one at Norfolk, Nebraska, and one at Chino, California. In the same year a factory was constructed by another group at Lehi, Utah, the first of its kind in the Intermountain area.

Other persons were prominent in this era of transition from pioneering setbacks to genuine success for the United States beet sugar industry.

One was Dr. Lewis S. Ware, a wealthy engineer and chemist, who spent large amounts of his own money distributing beet seed and literature in efforts to convince farmers and businessmen that the sugar beet was a desirable crop and that beet processing could be a sound business venture. Among the people he convinced were Mr. Dyer and Mr. Spreckels, whose successful factories justified Dr. Ware's confidence.

Another important influence during this period was Dr. Harvey W. Wiley, who won fame also as a sponsor of the Food and Drug Act. Chief chemist of the United States Department of Agriculture from 1874 to 1913, Dr. Wiley was officially as well as personally a sugar beet enthusiast. He distributed seeds to farmers and after making 8,000 analyses of beets grown in almost all the states of the Union, published an uncannily accurate map designating the most favorable areas for sugar beet growing in the United States. Later development of the industry has been almost entirely within the areas he indicated.

A third influential figure was James ("Tama Jim") Wilson, noted Secretary of Agriculture under Presidents McKinley, Theodore Roosevelt, and Taft. A firm believer in the importance of the sugar beet to the nation's future agriculture, Mr. Wilson was unremitting in his efforts to enlist capital for building new factories — so farmers could have a market for their beets. Seventy of the seventy-nine factories existing in 1915 were built during his tenure of office.

This official recognition and assistance of the Department of Agriculture were important to the continued progress of the newly-proven industry, but the governmental encouragement was also justified by the spread of the industry to other states after the successes in California and Nebraska. By 1900 thirty completely equipped beet sugar factories were operating successfully in eleven states from New York to the West Coast. It was evident at the turn of the century that the sugar beet had become at last firmly rooted in the economic as well as the agricultural soil of the United States. The industry was indeed national in scope.

The Industry Today

From those pioneering efforts and initial successes has emerged the American beet sugar industry of today. An integral part of the economy of twenty-two states, the industry exerts a beneficial influence that is felt throughout the nation.

For many thousands of farm families the sugar beet provides a major source of income and purchasing power, as well as a key to sound farm operations. More than three-score modern beet sugar processing plants — a far cry from the first crude factories at Northampton and White Pigeon — pour forth a stream of sparkling white, pure beet sugar that annually meets nearly one-fourth of the nation's sugar requirements.

A quick look at the extent of the industry that grew from those faltering beginnings may be obtained from the map on the opposite page. Further details will be found in tables in the Appendix, beginning on Page 78.

Chapter Four

THE SUGAR BEET IN AMERICAN AGRICULTURE

The Beet Means More Than Sugar

About the time the Mormons were making their first strenuous attempt to establish the beet sugar industry in Utah, a significant episode occurred in France. It helped to explain why foresighted Americans of that day believed the sugar beet could contribute importantly toward developing a well-rounded agriculture in this country. And it illustrated a fact that many American farmers later learned — that sugar beet culture brings benefits to agriculture extending far beyond the production of sugar itself.

In 1853, when Napoleon III, and his bride, Eugenie, were touring France, the peasants of Valenciennes built a triumphal arch to welcome them and to honor the two Napoleons who fostered the beet sugar industry. Across the top of the arch appeared the legend, "Sugar Manufacture," and under it, the likeness of Napoleon I, "Who Created It," and Napoleon III, "Who Protected It."

Under the portrait of the first Napoleon was the inscription:

> "Before the manufacture of beet sugar the *arrondissement* of Valenciennes produced 695,750 bushels of wheat and fattened 700 oxen."

And under the image of Napoleon III, the "protector," the words were:

> "Since introduction of the manufacture of beet sugar the *arrondissement* of Valenciennes produces 1,157,750 bushels of wheat and fattens 11,500 oxen."

Here was an increase, credited to the sugar beet, of 66 per cent in wheat production, and a gain of more than 1,500 per cent

in livestock fattening. If it seems curious that the amount of sugar produced was not mentioned, the omission merely emphasizes the attitude held by some Europeans that sugar is a by-product rather than a primary product of beet culture. While this attitude may unduly minimize the value of the sugar obtained from the beet, it does accentuate the striking effect of the sugar beet on the agriculture of the areas where it is grown.

For unlike many other crops the sugar beet serves more than one purpose. It has earned its eminent position in American agriculture for three primary reasons:

(1) It promotes soil fertility and sound farming practices. The sugar beet requires and therefore brings about a progressive system of diversified farming. Yields of other crops traditionally improve following beet production.

(2) By-products of the sugar beet provide an important feed for beef cattle, sheep, and dairy herds. In many areas the beet thus promotes a sound crop-and-livestock farm operation.

(3) Because of the sugar it produces, the beet is an important and dependable cash crop. For many farm families, the sugar beet is the most reliable source of income, year after year.

The Sugar Beet in Crop Rotation

One reason for the sugar beet's unique position in agriculture is its importance in a sound crop rotation. Good farming practice requires a variation in crops. Continuous planting of the same land to the same crop year after year almost inevitably results in agricultural and economic troubles. At least one of the crops in a good rotation should be an intensively cultivated row crop — such as sugar beets, corn, potatoes, cotton, beans, tobacco and garden vegetables.

Successful production of these crops requires a loosening of the earth around the plants at intervals during growth. This action breaks up crust and clods, improves the physical condition of the soil. It destroys weeds while they are still young and prevents their reseeding and dispersion. Sugar beets require cultivation not only between the rows but also between the plants in the row. Introduction of sugar beets has been a principal factor in controlling weeds in many farming areas. On the other hand, with continuous planting to hay, grain or other crops which are not

ordinarily cultivated after planting, the land gradually becomes infested with soil pests, weeds and other foreign growth, and subject to inroads of plant diseases and insect pests.

Rotation is essential for many reasons other than the benefits of cultivation. In fact, cultivated crops themselves often are alternated, such as tomatoes, beans and other row crops in some areas. Plants feed at different depths in the soil. A plant with shallow roots, such as beans, tends to exhaust soil nutrients near the surface and should be alternated with a "deep-feeder" having long roots that tend to obtain more of their nutrients at deeper levels in later stages of growth. Moreover, different plants, even if feeding at the same level, may require varying proportions of a given soil element; rotating crops helps to prevent exhausting all the available supply of a single element. Rotation thus promotes soil equilibrium. Decaying residues of previous crops increase the amount of organic matter in the soil and benefit crops to follow. Pests which harm one crop may not affect another — may, in fact, die out when another crop is grown in the soil.

Proper rotation is essential, yet climate and soil impose limitations. Few crops grow well in all latitudes or in all soil types. Sugar beets grow successfully in areas where conditions rule out certain other crops. Beets thrive throughout the northern latitudes of the United States, in Canada, and as far south as the Mexican border, at elevations varying from below sea level to an altitude of 7,000 feet, and in a wide variety of soils. The crop exhibits a unique tolerance to alkali, which is present in large areas of land in arid regions of western states. Extensive development of such lands has been materially helped in many instances by the introduction of sugar beet culture.

The form and nature of the beet itself help explain why general farm conditions improve where sugar beets are grown. The root system penetrates the ground to as much as six or seven feet, a mechanical disturbance beneficial in itself. When the beet is pulled at harvest time, the greater part of the feeder-root system remains in the ground. Decomposing, it contributes to fertility. Beet tops, removed from the rest of the plant during the harvesting process, sometimes are plowed under, thus serving as "green manure" and adding further to the soil's fertility.

The increased yield of other crops in the beet rotation depends, of course, on many factors — such as management skill, type of soil, climate, irrigation and rainfall. Nevertheless, it has been conservatively estimated that a 15 per cent increase in the yield of wheat and a 10 per cent increase in yields of some other

crops may be expected when the beet is introduced into the cycle of rotation. Other instances have been reported of 75 per cent higher yields of some other crops following the introduction of beet culture to the land.

By-Products for Livestock Feed

The sugar beet is literally two crops in one. Its principal product, sugar, is a vital energy food for human beings. Sugar beet by-products — tops, pulp and molasses — are highly nutritious feeds for livestock, and thus provide additional food and fiber for human beings as meat, milk and wool. (By-products that have non-agricultural uses will be discussed in Chapter Six.)

Years of experience in many parts of the country have shown that sugar beet by-products, fed with grain and alfalfa hay, will produce beef and mutton or lamb at lower cost than any other ration available in the United States, not even excepting the grain and alfalfa combinations fed in the corn-belt.

Sugar beet tops — the green leaves and a section of the "crown," or upper part of the beet — contain nearly 10 per cent digestible protein (on a dry matter basis) and show a marked Vitamin A effect when fed green or siloed green. Tests conducted over a fourteen-year period at a University of Nebraska experiment station showed sugar beet tops, pound for pound, equal to corn silage. "Pound for pound they are as good a source of feed roughage as alfalfa hay," the University of California found after exhaustive tests. In his book, *Beets and Meat,* E. J. Maynard points out that tops are also a fattening feed and that "each pound of well cured, dried tops is approximately equal to, or will replace, about one-half pound of grain."

In some areas, cured tops are baled and sold to commercial feeders if the beet farmer or his neighbors do not have feeding operations. Cured tops are also stacked and fed like hay. The fullest feed value of the tops is retained when they are siloed as soon as possible after removal from the beet. Many farmers have machinery that elevates the fresh, clean tops to trucks as part of the beet harvesting operation, for immediate hauling to silos. An acre producing twenty tons of beet roots for sugar will generally yield twelve to fifteen tons of green tops.

Beet pulp is the vegetable portion of the beet that remains after the sugar is removed in the processing plant. No less than beet tops, beet pulp is sought by dairymen and cattle and sheep feeders for their livestock. Sugar beet pulp contains carbohy-

drates and also signficant quantities of protein and minerals. At some factories, pulp is stored in wet form and sold to farmers as they need it in their feeding operations. More commonly, however, most of the moisture is removed through mechanical pressure and evaporation, and the pulp is sold in dried form. Dried pulp is a concentrated livestock feed. Beet molasses is often added before the evaporation step, producing "molasses-dried" beet pulp. When the molasses is not added, the finished product is known as "plain dried" beet pulp. Dried pulp is also compressed into pellets for easier handling of the bulky material.

Another variation is ammoniated beet pulp. Cattle feeding tests at Oregon State College have shown it to be high protein feed giving results equal to or better than cottonseed meal.

Dried pulp is widely used as a basis for mixed feeds. It is used in the dairy, in the feed lot, and often as a supplemental feed on the range. Feeding experiments at state agricultural colleges have shown that "molasses-dried" beet pulp approximates the feeding value of corn, with certain additional benefits corn does not possess. A higher rate of animal survival results from the addition of sugar beet pulp to the ration, for in its specific effect on the animal, particularly the dairy cow, dried beet pulp goes beyond the properties of corn. To maintain high milk production, there is often a tendency to feed too heavy a grain component, which may cause death losses. But with dried pulp, which is bulky, fluffy, palatable, nutritious and highly absorptive, both the productivity and reproductivity of the dairy herd can be held at the most efficient level. Dried beet pulp increases the digestibility of other feeds in the ration.

Beet molasses is also a by-product of the sugar-extracting process. Although much molasses is mixed with pulp before the final drying, some molasses is also sold separately for mixing with other feeds. It may be added to practically any ration. Molasses gives the entire ration such an increased "taste appeal" that it has a replacement value equivalent to grain when the molasses is used in proper quantities. Manufacturers of mixed feeds recognize this desirable quality and often use molasses in their products.

The use of the sugar beet's by-products as livestock feed is another reason why the beet promotes better farming practices and builds a sounder agriculture. Beet tops, beet pulp in its various forms, and beet molasses have built an extensive sheep and cattle feeding industry in areas where corn and other feed crops have been relatively expensive. Through animals, nutrients taken from the soil by growing crops are restored to the land as manure,

and soil fertility is maintained. The by-products of the sugar beet therefore contribute to the stability of farms, towns and states.

An acre of land yielding twenty tons of beets will produce approximately 6,000 pounds of pure granulated sugar, and the by-products of the same acre, when included in a ration fed to livestock, will produce from 400 to 600 pounds of meat or 5,000 to 6,000 pounds of milk. When by-products are fed on the farm that produced the beets, most of the vegetable part of the beet is returned to the soil through manure.

Refined sugar contains only carbon, hydrogen and oxygen. Thus millions of bags of sugar can be shipped out of beet-producing areas, yet leave behind the "big three" soil elements — nitrogen, phosphorus and potash — for return to the land. The sugar beet, therefore, is one of the most efficient crops known. No other crop grown in the temperate zone produces per acre so much food for man and feed for livestock as the sugar beet.

The Sugar Beet Is a Vital Cash Crop

To the farmer, cash income is a primary consideration in determining how he will invest his time and capital, and what he will produce from his labors. A compelling reason for growing sugar beets is that the beet is a dependable and highly valuable cash crop. The farmer contracts for the sale of his beets before he plants them; he has an assured market for his crop even before the seed is in the ground. Income from sugar beets, therefore, is something the farmer can count on, year in and year out, as a basis for the financial planning of his operations. The banker looks with favor upon the farmer who grows beets.

The early-day farmers needed a dependable cash crop that also had other attributes. Transportation to the populous markets for the products of the land was difficult and costly from this then remote country. In the sugar beet they found a cash crop and an answer to this perplexing problem. A ton of sugar beets went to distant markets as a few hundred pounds of sugar — taking little room in the box car and not piling up shipping charges that ate up the profits. Meat produced from beet by-products also served the need for a concentrated food to ship. Moreover, as the 200-foot smoke stacks of the sugar factories began to rise from the plains, another great need of the West was being met — manufacturing payrolls to supplement the income of the farmers and bring economic stability to the communities.

First through private initiative and later through reclamation programs of the government, irrigation projects brought water and life to the dry acres of the West. But a dependable cash crop was needed to form a basis for the financial success of the projects, as well as the financial success of the individual irrigation farmers. Sugar beets again provided the answer. Beets paid the water bills and lifted the mortgages. The Federal Reclamation Bureau consistently includes sugar beets as one of the recommended crops in new projects. Referring to the sugar beet industry as "the backbone of those federal reclamation projects where the crop is grown," a noted Commissioner of Reclamation, Elwood Mead, extolled the virtues of the sugar beet in words that still hold true today:

"It is one crop that contributes more than anything else to a rounded-out, complete agricultural program, gives winter and summer employment, enables the farmer to make the largest and best use of the surrounding grazing land, largest and best use of the alfalfa that is grown, and gives in an unusual measure a continuous employment for the family on the farms, with more stable income than anything else."

From Europe has come the statement that "if the sugar beet did not exist it would have to be invented." No one has yet invented — or discovered — another crop to equal the beet as a vital and dependable cash crop for vast regions of this nation, or as a crop that contributes so much to a well-rounded agriculture with benefits spreading to the entire nation.

Chapter Five

THE REVOLUTION IN BEET FARMING

All American agriculture has undergone a great mechanical revolution in the last third of a century, and the sugar beet farmer's method of producing his crop provides an example of the effects of this change. Ingenious machines have greatly reduced the amount of hand labor formerly required in beet production — just as the grain combine has replaced the laborious tasks of shocking the sheaves and loading the bundle wagon, so common in the wheat field a comparatively few years ago. Developments now in the laboratory, experiment station and machine shop promise still further changes.

Mechanization of sugar beet production plus improvement of beet seed strains and the application of more advanced farming methods have combined to raise the efficiency of American sugar beet farmers to new levels. According to officials of the United States Department of Agriculture, nowhere in the world are sugar beets produced with fewer man-hours per ton than in the United States. In fact, no foreign country produces any sugar crop — beet or cane — with fewer man-hours of field work per ton of sugar than are now required in the average American sugar beet field.

Harvest Now Completely Mechanized

The harvest was among the first of the major sugar beet field operations to be taken over by the machine. Adoption of mechanical harvesting came swiftly after practical machines were developed. The first began to appear in numbers soon after World War II, and in less than ten years the sugar beet harvest in America was virtually 100 per cent mechanized.

The harvest involved several distinct operations, and it was no simple task to develop a machine capable of performing them all. The traditional harvest was handled like this: A horse- or

tractor-drawn "beet lifter" loosened the beets, then laborers pulled them, sliced off the crown and leaves with a broad-bladed beet knife, and heaped the beets in a pile for scooping into a wagon or truck. Despite the complicated nature of the beet harvest, several machines have been devised which perform all the operations in a single trip down the beet row — and, in addition, load the topped beets into trucks for hauling to the sugar factory.

To conserve the rich, green tops for livestock feed, some machines harvest the beet leaves separately, chopping and loading them into trucks for hauling to silos. Another kind of machine beats off the leaves with rubber flails, pulverizing the leaves for quicker disintegration when plowed under as "green manure." Another "scalps" the crown, leaving only the main part of the sugar-filled root in the ground for pulling and loading by another machine. Mechanical harvesters in most common use, however, perform all the operations in one trip through the field — pulling, topping and loading.

Implement manufacturers, scientists and management of the beet sugar processing companies, scientists of state agricultural colleges and the federal government, and the beet growers themselves have all cooperated to develop the variety of mechanical equipment now seen in American sugar beet fields at harvest time. For example, two of the first successful harvesters were developed — one in a small machine shop, the other by a major manufacturer — from basic ideas conceived by two beet growers, one in California and one in Colorado, working at the same time but independently of each other. To perfect the two machines, other growers and sugar company experts cooperated in field trials.

Some of the various types of harvesters in general use are shown in the accompanying illustrations.

Hand Blocking and Thinning Are on the Way Out

Similar cooperation has resulted in widespread mechanization of other phases of sugar beet production. Operations common to most crops — plowing, land leveling, disking, planting, etc. — have long been done mechanically by sugar beet farmers. But certain growing-season operations peculiar to beet production — blocking, thinning and cultivating between plants — are tasks that posed particularly difficult problems to the inventors of machines.

In mechanizing these operations, the work of agricultural engineers has been complemented, particularly in recent years, by

the research of plant scientists — because the basic problem was the beet seed itself. Blossoms on the normal sugar beet plant grow in clusters, and each cluster of flowers produces a group of seeds held together as a hard, tight ball covered with corklike material. When a seed ball is planted, therefore, two, three, four or more seedlings emerge, all close together and often intertwined.

Since the beets require "elbow room" for proper growth, they should be thinned to a point at which the plants stand at proper intervals in the row — six to twelve inches apart, depending upon soil and climatic conditions. In the traditional method of blocking and thinning, workers went through the field of solidly planted rows with short-handled hoes, first removing solid blocks of seedlings and then removing by finger work all but one plant from each blocked bunch.

This work must necessarily be done when the plants are small, about a month after planting, when four true leaves have appeared on each plant. Because the plants from a normal seed ball sprouted so closely together, a thinning machine could not be devised which would eliminate most of the plants and leave spaced single plants standing. The initial effort, therefore, had to be toward developing a beet seed ball which would produce only a single shoot.

The first substantial progress on this score was made in the early 1940's by scientists at the University of California, working under a grant provided by beet sugar companies. The researchers developed a method of reducing, by mechanical means, the number of seed germs in a seed ball and of mechanically sizing the reduced segments to uniform dimensions. This process was a tremendous advance. After various planting trials, the new "segmented" seed became the accepted seed for all sugar beet planting in the United States. This development alone has reduced the hand labor requirement by as much as 25 per cent. Only four to six pounds of processed seed were required to plant an acre, compared with eighteen to twenty pounds of whole seed.

Planting drills were adapted to handle the new, smaller seed and to drop it at spaced intervals instead of solidly in a row as had been the practice with the old seed. This opened the way for development of mechanical blocking and thinning. On smooth ground, an ordinary cultivator was found practical for drawing across the rows to eliminate excess plants. For ground with irrigation ditches between the rows, a thinner for use down the rows was developed. This consists of a series of small revolving blades, spaced according to a mathematical formula to remove excess

plants and leave enough for a good stand. The same implement has been found practical for reducing the weeds that may grow between the remaining plants. Thus for the first time since the industry started, in-the-row thinning of beets and destruction of weeds between plants have been accomplished mechanically.

Processed seed and mechanical devices have reduced the amount of spring and summer hand labor by at least 50 per cent in some areas, and the labor still required can be done with a long-handled hoe, a real improvement over the short-handled hoe and finger-thinning formerly used. It was early recognized, however, that the final answer had not yet been found, because processing the seed ball did not always result in single-germ segments; two and sometimes three plants still occasionally grew from a single segment. And so the relentless search for a true single-germ or "monogerm" sugar beet seed continued.

Success on this score came in 1948, when two plants with the true monogerm character were found in an Oregon beet seed field. It was a momentous discovery, and followed examination of thousands of plants. The seed from those two Oregon plants was taken to the laboratory, and then came the slow, painstaking work of breeding the monogerm character into the seeds that would produce plants with high yield and disease-resistant qualities. By 1958 plant geneticists — in sugar company research departments, and state and federal experiment stations — had progressed enough in developing monogerm seed, with desirable characteristics, to permit significant commercial plantings. This seed, along with other developments — such as precision planters, mechanical and chemical weed killers, and constantly improving farming methods — provided the basis for forecasts that in time all phases of sugar beet production in the United States will be fully mechanized.

Other Advancements

Although perhaps not quite so spectacular as the recent growth of mechanization and the introduction of processed and monogerm seed, many other developments have taken place over the years. These include the continuous improvement of beet yields and sugar yields per acre, more effective use of both commercial and natural fertilizers, better irrigation methods, and the breeding of plants ever more resistant to diseases, insects and soil pests. All these have led to greater production of beets and sugar with the expenditure of fewer hours of human labor.

For example, in 1900 the average yield of beets was 6.4 tons per acre; in 1935, 10.4 tons; and in 1957, 17.7 tons per acre. Sugar produced per harvested acre, on the average, for the five-year period of 1950-54 was 16 per cent greater than during the five-year pre-war period of 1937-41. U.S. government experts on the subject estimated that in 1958 only about 3.5 man-days of work in the fields were required to produce the beets needed for making a ton of sugar, a reduction of almost one-third since 1948. Tests made by state colleges show that with complete mechanization of both thinning and harvesting, beets sufficient to make a ton of sugar may be produced with only 2.3 man-days of labor in the fields.

Still further increases in per-acre production in the United States can be expected from another development now on the threshold. Plant scientists are perfecting hybrid sugar beet seed on the same principles as the hybrids which so increased United States corn production per acre. Some of these new hybrid varieties have the monogerm character.

Beet Seed Now Produced in United States

Various reasons can be given for the constantly increasing production efficiency of the American sugar beet farmer — in addition to the traditional American attitude of looking at this year's new production record not as a final plateau but merely as a challenge, as something to be beaten next year.

One reason is that all sugar beet seed now used in the United States is a product of this country's research and thus is better adapted to American soils, climates and agricultural hazards. In the beginning of the beet sugar industry here and for many years thereafter, growers relied upon European sources for all or nearly all their seed. When supplies were virtually cut off during the first World War, commercial seed production started in the United States (in 1916) but was abandoned a few years after the war because of the amount of costly hand labor then involved. Again we turned to Europe for seed. The story of how sugar beet seed production became practical in the United States is a curious one.

The sugar beet plant is a biennial. In its first year it sinks a root and stores energy to be used the following year for producing seed. Normally the root is harvested the first year for sugar. But if permitted to grow a second year, the plant sends up a tall stalk which bears the seed. Under the European method of seed production, the roots were pulled from the ground in autumn of the

first year of growth, stored through the winter, and replanted the following spring. Seed then grew on a thick, woody stalk. To harvest the seed, workers hacked off the stalks with heavy knives. All in all, this was hard work and decidedly costly under American wage scales. An American method to replace this procedure was found partly by accident, partly because of the acute observation of scientists.

Some years ago farmers in southeastern New Mexico attempted to grow sugar beets but with uniformly unsuccessful results. Thereupon experiments were conducted to find the best time of year for New Mexico plantings, simply by planting some beets in every one of the twelve months. It was probably a shock — certainly a disappointment at first — for the experimenters to discover that beets planted in the late fall months began, in the following spring, to send up seed stalks rather than to store sugar. Winter frosts had stopped the growth of the immature beets just as effectively as if they had been pulled up and siloed during the winter. But alert plant scientists with the New Mexico Agricultural Experiment Station and the United States Department of Agriculture recognized that this apparent nuisance was in reality a boon — not for sugar production but for seed production. The seed stalk produced by this over-wintering method was a triumph in itself. Only as thick as your thumb, it could be cut down with a mechanical mower. A tremendous amount of manual labor had thus been eliminated. Here was a new method of producing beet seed adaptable to areas having quite mild winters, yet with temperatures low enough to give the plant the "over-wintering" experience.

Beginning in the early 1930's, the American sugar beet seed industry was re-established, and grew rapidly as strains particularly adapted to the beet growing areas of this country were developed. Since 1941 the United States has imported no seed for commercial sugar beet production. Production of most of the seed used commercially in the United States — some 13 million pounds annually — is directed by two companies owned by groups of beet processing companies. Farmers grow the seed under contract with the seed companies.

Discovery of the over-wintering procedure has materially speeded development of improved seed strains. Several experiment stations now have refrigerated rooms where they can artificially induce winter temperatures to speed up the seed-producing process and thus reduce the time between generations of plants.

Close Relationship Between Grower and Sugar Company

Not the least of the reasons for continuous progress of the United States beet sugar industry is the close relationship between growers and the sugar companies. The grower buys his seed from the company, he grows beets under contract with the company, and all through the year the agricultural staff of the company provides a medium for exchange of information and ideas.

An important link in this information chain is the company fieldman, a highly-trained agricultural expert. He counsels with growers individually and at meetings, where he may show motion pictures and slides produced by the company to demonstrate improved methods of sugar beet production. Many companies also publish magazines for growers. These magazines regularly report on new and proven research developments and relate the experiences of growers with new practices.

One reason for the close relationship between producer and processing company is the unique contractual arrangement under which sugar beets are marketed. The amount a farmer receives per ton of beets is based on the sugar content of the beets and the final net return to the sugar company from the sale of sugar produced from the year's crop. This is the only case in the United States in which — on an industry-wide basis — the farmer's income for his crop bears a direct relationship to the net return received by the processing company from sale of the processed crop. This tends to give producer and processing company a mutuality of interest distinctive in American agriculture and industry.

Exchange of Scientific Information

A basic factor in the success and progress of any major industry today is the extent of research and the availability of information about scientific developments in the same or a related field. Each of the major beet sugar processing companies has its own research staff, and there is a full and free exchange of technical information among the technicians and scientists of the companies and of the state agricultural colleges and the Department of Agriculture.

A professional organization, the American Society of Sugar Beet Technologists, headquartered at Fort Collins, Colorado, serves as a forum for the exchange of information by holding national and regional meetings and publishing scientific papers. The

Society also maintains contacts with sugar beet scientists elsewhere in the world and disseminates information received from them.

Another organization, the Beet Sugar Development Foundation, of Fort Collins, Colorado, advises state and federal experiment stations on the relative importance to the industry of proposed sugar beet projects and also channels research grants provided by the sugar companies.

Beet sugar companies also help support the Sugar Research Foundation of New York City, which sponsors research to expand knowledge of sugar and its role in nutrition and food technology. Since sugar is a component of so many hundreds of commercially-prepared foods, it is essential to learn in what quantities and under what conditions it can best be used to enhance the nutritional values, flavor, and other factors of quality. Projects conducted with the help of grants from the Foundation also include research involving the use of sugar in non-food products, such as surface coatings (paints and varnishes), plastics, agricultural chemicals, detergents, fibers, films, solvents, explosives and adhesives. This research suggests that the mechanical revolution which has so transformed sugar beet production may, in the years to come, be matched in the scope of its effects by a chemical revolution leading to new uses of sugar in non-food products.

Chapter Six

EXTRACTING SUGAR FROM THE BEET

At the height of the sugar-making campaign, a beet sugar factory presents a series of memorable impressions — the droning hum of motors; the splash of water in the beet-washing tanks; the whiz of wide conveyor belts; the whir of giant centrifugals; the clatter of sugar packaging machinery; and also, in contrast, the quiet watchfulness of factory technicians at the control panels of automatic and semi-automatic processing equipment.

Outside the factory rise piles of beets — in cool regions often covering acres, with ventilating tubes passing through the piles. Farmers bring more beets in a continuous stream of trucks. Various devices receive the beets — elevated trestles, power-driven belts and portable machines that deliver truck loads to the piles.

Long freight trains roll into the bustling factory yard with still more beets from outlying stations. The brimful cars climb the trestles, or dump beets into bins or into "wet hoppers" — concrete trenches from which beets are flumed into the factory.

Beside the factory are stocks of coke, limerock and, unless oil or gas is the principal fuel, huge piles of coal. On the average it requires thirty-five pounds of coke and limerock and sixty pounds of coal to produce a hundred pounds of sugar.

The visitor to the factory during the campaign sees on the one hand thousands of tons of beets arriving; on the other, freight cars being loaded with pure, refined sugar from the warehouse; and in between, a wide panorama of industrial activity.

The Basic Processes

The work of extracting sugar from the beet consists of basic processes that sound simple enough: the sugar first is soaked from

the beet in liquid form; the resulting juice then is purified, concentrated, and crystallized; and finally the crystals are separated from the remaining liquid.

Actually, sugar chemistry is infinitely complex, and intricate engineering problems are involved. Specific processes include such operations as diffusion, precipitation, filtration, evaporation, crystallization and centrifuging. In fact, most of the important so-called "unit processes" of chemical engineering are represented in a beet sugar factory.

While details of methods and equipment vary somewhat among factories and in different parts of the country, the following description may be considered to be a general outline of the processes that take place in a typical factory.

Cleaning and Slicing the Beets

Cleanliness is a watchword throughout a sugar factory, and cleanliness begins with clean beets. Most of the bits of earth that cling to the beet when it is pulled from the ground are removed before the beets are delivered to the storage area, bins, or flumes.

Water in the flumes, carrying the beets into the factory, washes off more dirt and softens what may remain. "Trash catchers" of various types remove whatever other foreign matter may still be mixed with the beets, such as bits of grass or leaves. Still the cleaning process is not complete.

As they enter the final washer, the beets are subjected to a high pressure spray of water, then swished around by rotating paddles or pulled on an endless chain system moving counter to a stream of water. Another high pressure spray rinses the beets as they leave the washer.

The thoroughly cleansed beets are now ready for the first stage of actual processing. They fall through a hopper into revolving knives, which cut the beets into thin strips that look something like "shoe-string" potatoes. The slices, which are V-shaped, are known as *cossettes*, one of the many French terms used in the industry. Factory workers call them *chips*.

Removing Sugar by Diffusion

Now comes the process of removing the sugar from the cossettes. This is accomplished by soaking the thin beet strips in hot water, in a huge container called a *diffuser*. This action takes the sugar from the tiny plant cells and diffuses it through the hot

water. Fresh hot water first reaches the cossettes from which the most sugar has been taken and then moves, with its temperature carefully controlled, through a series of compartments in a direction opposite to the movement of the cossettes. As it progresses through the diffuser, the liquid removes additional fractions of the sugar in the chips and finally contains enough sugar to be called *raw juice.*

In a typical modern factory the huge diffuser, which weighs some three hundred tons, is run by one man who controls the operation principally by push buttons.

With their sugar removed, the cossettes now are called *beet pulp* and are conveyed to the pulp dryer or to the storage place for wet pulp. The *raw juice,* which has a sugar content of 10 to 15 per cent but also contains some non-sugar substances, now goes to the purification stages.

Purification of the Juice; Evaporation

Two main processes are used in removing the non-sugar substances from the juice. First these substances are precipitated or coagulated. This is followed by a filtering process which removes the non-sugar substances.

Milk of lime and carbon dioxide gas are used in the precipitation stage. Both the lime and the gas are made by burning limerock and coke in a lime kiln. The milk of lime, a suspension of lime in water, absorbs or coagulates part of the non-sugars and makes them insoluble; the carbon dioxide in turn makes the lime insoluble. When the juice is run through batteries of filter presses, then, the lime is filtered out and with it go the non-sugars.

To make doubly sure of removing impurities, the raw juice twice goes through this carbonating and filtering process. Now known as *thin juice,* it requires thickening before sugar crystals will form readily.

This is done by running the thin juice through a series of five evaporators. Called multiple-effect evaporators, they provide an example of one of the many economies that have been effected to achieve efficiency of beet sugar production. Because the process of extracting sugar requires quantities of both steam and electric power, the factory has huge boilers and electric generators. The live steam from the boilers is used first to operate the generators. Then it is used five times over in the evaporators to concentrate the thin juice to a thick juice. Of course the steam loses some of its heat in each evaporator. To compensate for this, the pressure

in each succeeding evaporator is decreased; this enables the liquid to boil at a lower temperature.

The concentrated juice coming from the evaporators is called, appropriately enough, *thick juice.* It now has a sugar content of 50 to 65 per cent — instead of the 10 to 15 per cent it had in the raw juice stage. Further filtering of the juice plus the addition of intermediate and raw sugars produced later in the process yields a sparkling, clear liquid known as *standard liquor.*

Forming Sugar Crystals

The next major stage in the processing is to change the sugar in the juice from liquid to crystal form.

Crystallization is achieved by boiling the standard liquor in huge tanks called vacuum pans. To prevent burning and caramelization, the boiling must be done at a comparatively low temperature; hence a high vacuum is necessary. The standard liquor is boiled until it reaches a state of supersaturation. A sugar solution is said to be supersaturated when there is a greater ratio of dissolved sugar to water than could normally exist at that temperature. Then, by injecting a small amount of pulverized sugar, the liquid is *seeded* — and sugar crystals begin to form.

Control of the crystallization process is an art, and the process is conducted by a skilled technician. By regulating the vacuum and temperature, by adding more standard liquor when necessary, by using steam, he governs the growth of crystals until they reach the proper size. The sugar boiler takes frequent samples from the vacuum pans and examines the crystals under a magnifying device. The instant the crystals reach the desired size, the operator stops the crystallizing process.

The mass in the vacuum pan now is a thick mixture of crystals and syrup and although it is brown in color it is, strangely enough, known as *white fillmass.*

Separating Crystals from Syrup

The next step is spectacular. The fillmass is poured into high-speed centrifugal machines. Essentially the centrifugal is a huge revolving metal basket, perforated with extremely fine holes and surrounded by a stationary outer shell. After the fillmass is poured into the basket, the basket whirls at a peripheral speed of more than two miles a minute. This action throws the fillmass to the sides of the basket, and the brown syrup passes through the holes while the white crystals remain inside the basket. As

the machine spins, the brown color changes quickly to sparkling white. A jet of hot water sprays on the sugar, and this also passes through the perforations of the basket, washing off the last traces of the syrup.

The wet sugar now passes to granulators, where it is dried in a current of warm air. Then it is screened to sort crystals according to size and sent to bins or huge silos for later packaging or removal for delivery in bulk.

The syrup that has been separated from the sugar crystals and expelled through the holes in the sides of the centrifugal basket still contains considerable sugar in liquid form. This syrup undergoes two more boilings and centrifugings, during which it yields the intermediate and raw sugars that are added back to the thick juice for further processing.

Processing Molasses

The syrup thrown off by the third centrifuging is called molasses. It still contains some sugar in liquid form which cannot be economically recovered by additional boiling and centrifuging. A method known as the Steffen process, however, is used for recovering more sugar from molasses.

This process involves adding finely ground lime to a molasses solution. The sugar forms an insoluble compound with the lime, known as calcium saccharate. This is separated by filtration, thoroughly washed and returned to the sugar-making process, where it is mixed with incoming diffusion juice. The lime in the saccharate serves the same purpose in clarifying the diffusion juice as does the milk of lime.

Processors have also developed a way to extract still more sugar from molasses after it has gone through the Steffen process — by using barium hydroxide to precipitate additional sugar.

By-Products of the Sugar Factory

Since the beginning of the beet sugar industry in Europe, the value of beet pulp as a livestock feed has been recognized. Beet pulp consists of the cossettes — the sliced beets — after the recoverable sugar has been removed. Pulp and the agricultural uses of molasses have been discussed in Chapter Four.

Molasses also has a variety of industrial uses. It is used extensively in the fermentation industry, particularly in eastern states,

where it is used in the manufacture of citric acid, yeast, antibiotics, and other products.

A product of increasing importance in the household and in the food industry, monosodium glutamate, also stems from a by-product of the beet sugar factory. Concentrated Steffen filtrate, once considered a waste product of the Steffen process of extracting sugar from beet molasses, now is used in the manufacture of monosodium glutamate — which intensifies the flavor and increases the delectability of many foods. This process produces further by-products from the beet — potash fertilizer and high protein livestock feed.

A Thousand Laboratory Tests Every Day

With its multitude of processes, the sugar factory has been described as a chemical laboratory. But it has a laboratory of its own, too, where chemists and technicians conduct over a thousand tests every twenty-four hours to maintain the high quality of the factory's principal product— sugar.

These tests cover a wide range, and include testing the whiteness of the sugar, the size of the crystals, and sugar's behavior in certain uses, such as syrup-making and candy-making. The result is an assurance to the consuming public that beet sugar is 99.9+ per cent pure sucrose, unsurpassed for any food use.

Pure Beet Sugar Available in All Forms

Most of the sugar sold in the United States is in granulated form. Crystals are made in various sizes to meet special needs. (Incidentally, size of crystals has no bearing on quality.) Also to meet the needs of consumers, granulated beet sugar is packaged in many sizes of containers — from quarter-ounce single-service packets for restaurant and institutional use to 100-pound bags for industrial use. The most popular home sizes are five-pound and ten-pound paper bags and one-pound cartons.

Many industrial users — such as canners, candy-makers, bakers and soft drink bottlers — prefer to receive sugar in bulk or in liquid form. Beet sugar companies meet these requirements by shipping both bulk and liquid sugar in specially-lined railroad cars and trucks. Devices have even been developed in the beet sugar industry for dissolving granulated sugar in water while the dry sugar is being unloaded from a truck or railroad car at the customer's plant.

APPENDIX

TABLE 1. — BEET SUGAR FACTORIES IN UNITED STATES IN 1958 BY STATES

State	*Number of Factories*	*Daily Capacity (Tons of Beets)*
California	10	27,500
Colorado	15	29,400
Idaho	5	14,850
Iowa	1	1,800
Michigan	6	9,400
Minnesota	4	10,900
Montana	4	8,900
Nebraska	5	9,400
Ohio	3	3,550
Oregon	1	4,050
South Dakota	1	1,800
Utah	5	8,100
Washington	2	6,900
Wisconsin	1	1,100
Wyoming		5,700
Total	66	143,350

Source: United States Beet Sugar Association compilation.

TABLE 2. — SUGAR BEET ACREAGES HARVESTED, SUGAR BEET PRODUCTION, BEET SUGAR PRODUCTION IN UNITED STATES, ANNUALLY SINCE 1913.

	(1)	(2)	(3)	(4)	(5)	(6)
	Sugar Beets			Beet Sugar Production		
Crop Year[1]	Acreage Harvested 1,000 acres	Production 1,000 tons	Average Yield Per Acre Harvested tons	Tons Raw Value 1,000	100-lb. Bags Refined 1,000	Sugar Per Acre Harvested tons, raw value
1913	580	5,886	10.1	785	14,668	1.35
1914	483	5,585	11.6	773	14,441	1.60
1915	611	6,511	10.7	935	17,484	1.53
1916	665	6,228	9.4	878	16,413	1.32
1917	665	5,980	9.0	819	15,304	1.23
1918	594	5,949	10.0	814	15,219	1.37
1919	692	6,421	9.3	777	14,529	1.12
1920	872	8,538	9.8	1,165	21,780	1.34
1921	815	7,782	9.5	1,091	20,400	1.34
1922	530	5,183	9.8	722	13,500	1.36
1923	657	7,006	10.7	943	17,620	1.43
1924	816	7,508	9.2	1,166	21,800	1.43
1925	648	7,381	11.4	977	18,260	1.51
1926	677	7,223	10.7	960	17,940	1.42
1927	721	7,753	10.8	1,170	21,860	1.62
1928	644	7,101	11.0	1,135	21,220	1.76
1929	688	7,315	10.6	1,089	20,360	1.58
1930	776	9,199	11.9	1,293	24,160	1.66
1931	713	7,903	11.1	1,237	23,120	1.73
1932	764	9,070	11.9	1,452	27,140	1.90
1933	983	11,030	11.2	1,757	32,840	1.79
1934	770	7,519	9.8	1,241	23,200	1.61
1935	763	7,908	10.4	1,268	23,700	1.66
1936	776	9,029	11.6	1,395	26,080	1.79
1937	755	8,772	11.6	1,375	25,701	1.82
1938	931	11,579	12.4	1,802	33,688	1.93

(Continued on next page)

TABLE 4. — BEET SUGAR: PRODUCTION BY STATES, CROP YEARS SINCE 1935-36

State	*1935-36*	*1936-37*	*1937-38*	*1938-39*	*1939-40*	*1940-41*	*1941-42*
			(100-lb. bags, refined)				
California	4,776,092	6,201,616	5,758,873	6,741,870	9,060,265	9,317,154	6,202,267
Colorado	5,897,018	6,695,153	6,053,669	6,103,411	5,348,464	6,248,656	5,941,389
Idaho	1,439,248	1,827,581	2,000,559	2,855,520	2,547,049	2,904,616	2,133,081
Indiana	222,000	211,901	186,762	301,251	274,517	301,661	275,567
Iowa	290,152	257,594	254,251	432,172	370,038	428,138	288,891
Kansas	109,406	157,602	152,777	223,468	142,755	273,693	205,677
Michigan	1,949,895	2,328,597	1,581,944	3,427,364	3,237,790	3,348,989	3,167,357
Minnesota	666,747	462,082	739,942	913,617	680,970	891,274	692,238
Montana	1,675,256	1,827,505	2,431,080	2,837,370	2,800,599	3,269,444	2,356,848
Nebraska	1,908,225	2,107,298	2,258,368	2,705,911	2,114,782	2,302,958	2,417,620
Ohio	647,778	555,795	273,057	862,201	834,380	899,141	919,865
Oregon	—	—	—	698,570	719,840	748,000	699,360
South Dakota	338,549	125,273	134,794	307,316	177,357	246,671	220,062
Utah	1,527,893	1,398,642	1,622,324	2,212,149	2,011,772	1,476,622	1,635,269
Washington	96,178	108,046	286,366	571,981	642,828	645,170	630,120
Wisconsin	181,435	162,493	153,894	320,262	176,540	238,685	201,455
Wyoming	1,852,807	1,673,215	1,874,786	2,121,122	1,837,702	1,863,335	1,576,603
Total Bags	23,578,679	26,100,393	25,764,446	33,635,555	32,977,648	35,404,207	29,563,669
Total—(Short Tons, Raw Value)	1,261,459	1,396,371	1,378,398	1,799,502	1,764,304	1,894,125	1,581,656

(Continued on next page)

TABLE 4. (Continued) — BEET SUGAR: PRODUCTION BY STATES, CROP YEARS SINCE 1935-36

State	*1942-43*	*1943-44*	*1944-45*	*1945-46*	*1946-47*	*1947-48*	*1948-49*
			(100-lb. bags, refined)				
California	6,945,969	3,253,580	3,567,092	4,629,046	6,754,709	8,731,128	6,637,041
Colorado	6,457,614	4,966,810	4,597,131	5,459,351	5,375,262	7,575,511	4,121,133
Idaho	2,896,789	1,478,248	1,607,743	2,106,323	2,877,415	4,567,566	2,926,877
Indiana	355,181	62,721	—	—	—	—	—
Iowa	348,441	215,845	259,895	322,133	440,563	286,660	292,565
Kansas	180,041	101,033	128,350	144,176	168,295	241,735	105,972
Michigan	3,448,951	998,312	1,620,368	1,921,770	2,883,715	1,221,111	1,541,754
Minnesota	890,232	584,810	791,727	792,918	1,019,480	720,117	1,175,074
Montana	2,825,771	2,071,715	2,176,019	2,488,852	2,343,981	2,524,421	1,886,520
Nebraska	2,074,723	1,471,483	1,353,739	1,468,886	1,864,646	2,069,013	1,114,959
Ohio	1,082,767	211,427	333,635	565,787	611,151	329,256	358,153
Oregon	837,140	692,610	677,840	903,838	1,184,442	1,644,437	1,495,701
South Dakota	183,642	110,483	112,366	160,311	191,577	146,449	89,766
Utah	1,634,659	1,291,563	1,098,001	1,123,906	1,396,608	2,109,443	1,165,486
Washington	739,317	585,216	480,902	686,849	830,791	984,393	715,800
Wisconsin	155,716	113,292	139,611	169,809	164,166	368,213	154,822
Wyoming	1,236,561	557,038	792,399	975,838	1,158,902	1,324,408	765,672
Total Bags	32,293,514	18,766,186	19,736,818	23,919,793	29,265,703	34,843,861	24,547,295
Total—(Short Tons, Raw Value)	1,727,703	1,003,991	1,055,920	1,279,709	1,565,715	1,864,146	1,313,280

(Continued on next page)

TABLE 4. (Continued) — BEET SUGAR: PRODUCTION BY STATES, CROP YEARS SINCE 1935-36

State	*1949-50*	*1950-51*	*1951-52*	*1952-53*	*1953-54*	*1954-55*	*1955-56*	*1956-57*	*1957-58*
				(100-lb. bags, refined)					
California	8,239,866	10,716,559	7,259,193	7,554,664	10,194,165	12,067,847	9,050,179	9,431,015	11,240,300
Colorado	6,218,877	7,464,951	6,060,519	6,005,965	6,370,942	5,071,744	4,968,020	6,525,555	7,836,142
Idaho	2,509,882	3,638,938	2,892,297	2,502,624	3,675,051	3,952,099	3,293,208	3,769,041	4,408,812
Indiana	—	—	—	—	—	—	—	—	—
Iowa	427,828	389,516	467,570	344,186	355,323	238,320	141,683	297,350	231,371
Kansas	110,349	135,125	74,640	115,001	65,013	141,614	204,978	—	—
Michigan	2,338,176	2,909,407	1,561,181	1,461,992	1,527,124	1,528,072	1,996,229	1,797,857	1,972,172
Minnesota	1,450,679	1,378,000	1,828,709	1,716,377	2,028,638	2,701,568	2,550,577	2,781,638	2,667,926
Montana	2,050,336	2,272,283	1,569,316	1,495,709	1,806,025	2,038,666	2,241,587	2,477,915	2,577,635
Nebraska	1,486,305	2,179,070	1,720,570	1,957,116	2,098,999	1,836,199	1,596,911	2,365,930	2,364,582
Ohio	570,340	575,622	369,802	359,971	511,951	681,227	616,807	564,923	758,929
Oregon	1,299,345	1,519,529	1,276,790	1,270,888	1,453,938	1,674,157	1,392,174	1,535,735	1,647,755
South Dakota	153,552	211,636	180,536	232,712	191,943	268,981	232,352	301,613	245,077
Utah	1,245,404	1,518,910	1,111,240	717,104	1,201,772	1,529,621	1,198,178	1,382,209	1,364,153
Washington	850,224	1,184,345	1,144,514	1,324,334	1,937,714	2,042,518	1,483,805	1,914,240	2,247,664
Wisconsin	236,157	402,336	139,120	170,174	212,111	245,241	205,108	233,375	245,858
Wyoming	1,040,775	1,213,618	1,168,418	1,189,383	1,387,107	1,341,025	1,149,694	1,477,339	1,551,413
Total Bags	30,228,095	37,709,845	28,824,415	28,418,200	35,017,816	37,358,899	32,321,490	36,855,735	41,359,789
Total—(Short Tons, Raw Value)	1,617,203	2,017,477	1,542,106	1,520,374	1,873,453	1,998,701	1,729,200	1,971,782	2,212,748

Source: Compiled by United States Beet Sugar Association.

FOR ADDITIONAL READING

General

Cottrell, R. H. (ed.). *Beet Sugar Economics.* Caldwell, Idaho: The Caxton Printers, Ltd., 1952. 379 pp. (A comprehensive book on the industry, with emphasis on economics of sugar beet production and processing.)

McGinnis, R. A. (ed.). *Beet-Sugar Technology.* New York: Reinhold Publishing Corporation, 1951. 574 pp. (Another comprehensive book, with particular emphasis on technology of growing and processing sugar beets.)

Maynard, E. J. *Beets & Meat.* Denver: Through the Leaves Press, 1950. 102 pp. (A practical manual for fattening cattle and sheep with sugar beet by-products.)

Sugar Information, Inc. *Sugar.* New York: Sugar Information, Inc., c. 1950. 36 pp. (An illustrated story of the production and processing of sugar.)

————. *Sugar — Its Types and Uses.* New York: Sugar Information, Inc., 1954 (third edition). 32 pp. (Authoritative discussion of sugar and competitive products; of special interest to industrial users of sugar.)

————. *Sugar as a Food.* New York: Sugar Information, Inc., 1955. 32 pp. (Documented report on research studies involving food, nutrition, diet and health, and their relation to sugar.)

Sugar Research Foundation, Inc. *The Sugar Molecule.* New York: Sugar Research Foundation, Inc. Periodical. (Contains timely articles by authorities on sugar and its uses.)

Taylor, Fred G. *A Saga of Sugar.* Salt Lake City: Utah-Idaho Sugar Company, Deseret News Press, 1944. 234 pp. (Well-told and well-documented story of the beet sugar industry in the Rocky Mountain West, with emphasis on the dramatic endeavors of the Mormons in Utah.)

United States Beet Sugar Association. *American Beet Sugar Companies, 1957-1958.* Washington, D.C.: United States Beet Sugar Association, 1958. 16 pp. (Directory of beet sugar companies in the United States and Canada; published annually.)

United States Department of Agriculture. *The United States Sugar Program. Agricultural Information Bulletin No. 111.* Washington, D.C.: United States Government Printing Office, 1953. 34 pp. (Describes background and operations of the Sugar Act, with particular reference to the Sugar Act of 1948, as amended in 1951.)

Western Beet Sugar Producers, Inc. *The United States Beet Sugar Industry.* San Francisco: Western Beet Sugar Producers, Inc., 1956. 16 pp. (Pamphlet describing briefly the history of the industry and its place in the American economy.)

Technical

American Society of Sugar Beet Technologists. *Journal.* Fort Collins, Colo.: The American Society of Sugar Beet Technologists. Published quarterly. (Technical papers on wide variety of subjects concerning all phases of sugar beet plant breeding, growing, and processing.)

————. *Proceedings.* Fort Collins, Colo.: The American Society of Sugar Beet Technologists. Published biennially from 1940 through 1954. Has been succeeded by the *Journal,* above. (Technical papers presented at the biennial meetings of the Society.)

Statistical

United States Department of Agriculture. *Sugar Statistics.* 2 vols. Washington, D.C.: United States Government Printing Office, Vol. I 1957 (rev.), Vol. II 1954. (Statistics on sugar deliveries from areas marketing in the United States, and production and related statistics on domestic producing areas.)

————. *Sugar Reports.* Issued monthly. Washington, D.C.: Sugar Division, Commodity Stabilization Service, United States Department of Agriculture. (Current sugar production and distribution statistics.)

Children's Books

Allee, Veva Elwell, and Fogata, Robert. *From Sugar Beets to Beet Sugar.* Los Angeles: Melmont Publishers, Inc., 1956. 24 pp. (A simple, step-by-

step explanation of the sugar-extracting process, illustrated with full-page photographs. For younger children.)

Burt, Olive W. *Peter's Sugar Farm.* New York: Henry Holt and Company, Inc., 1954. 90 pp. (A delightful story of a boy who learns about sugar beets when his family moves to a farm. For children 9 to 12 years of age.)

For Teachers

United States Beet Sugar Association. *The Sugar Beet Goes to School.* Washington, D.C.: United States Beet Sugar Association, 1951. 16 pp. Manual plus student work sheets and four large wall charts. (A teaching kit designed as an interesting and effective unit of work for intermediate and upper grades. Can be used alone or with *The Beet Sugar Story* as a reference.)

Western Beet Sugar Producers, Inc. *Let's Talk about Sugar.* San Francisco: Western Beet Sugar Producers, Inc., 1955 (rev.). (A manual for home economics instructors. Presents important facts about sugar, its role in nutrition and in cookery. Includes taste testing and product judging procedure and sample score sheet. Can be used alone or with student leaflet, *Know Your Way with Sugar.* See below.)

————. *Know Your Way with Sugar.* San Francisco: Western Beet Sugar Producers, Inc., 1956 (rev.). 4 pp. (Classroom leaflet for students of home economics. Contains information and recipes for use of sugar in a variety of foods, including cakes, cookies, candy, quick breads, jellies, etc., and the use of sugar in canning and freezing.)

Recipes

Beet sugar may be used in all recipes that call for sugar. Western Beet Sugar Producers, Inc., 461 Market Street, San Francisco 5, California, has prepared an interesting series of recipe booklets available without charge, including the following titles: *Answers by the Canning Doctor, Candy and How, Fashions in Frostings, Just Desserts, The Way of All Cookies, Well Preserved, Sauce-y Toppings, Simple Desserts Made Fancy, Elegant Meringue, Springtime Pies.*

Company Publications

Several of the beet sugar companies publish periodicals for sugar beet growers and also issue other publications. A list of such material may be obtained from the United States Beet Sugar Association, 920 Tower Building, Washington, D.C., or from Western Beet Sugar Producers, Inc., 461 Market Street, San Francisco 5, California.

Motion Pictures

Motion pictures on the beet sugar industry are available for use in classrooms and for showing to other groups. Further information is available from Western Beet Sugar Producers, Inc., 461 Market Street, San Francisco 5, California.

Libraries

Several libraries in the United States have outstanding collections of books and other material on sugar beets and beet sugar. Among such libraries are the following:

Franklin Institute Library
Philadelphia, Pennsylvania

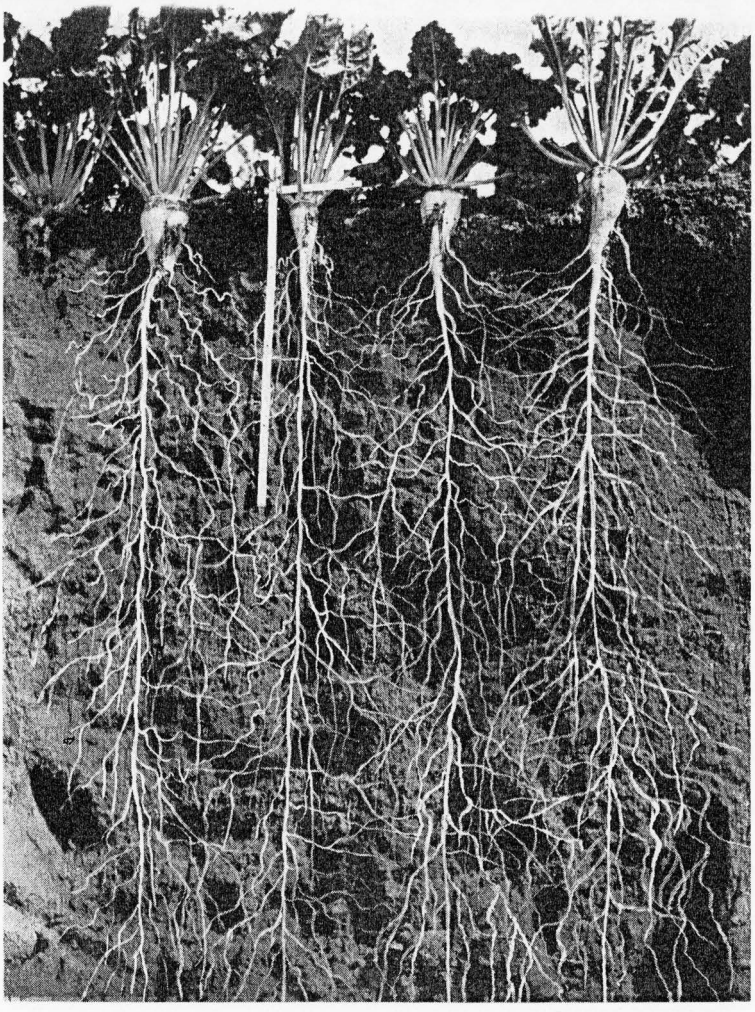
University of California
College of Agriculture
Davis, California

Colorado State University
Fort Collins, Colorado

Library of Congress
Washington, D.C.

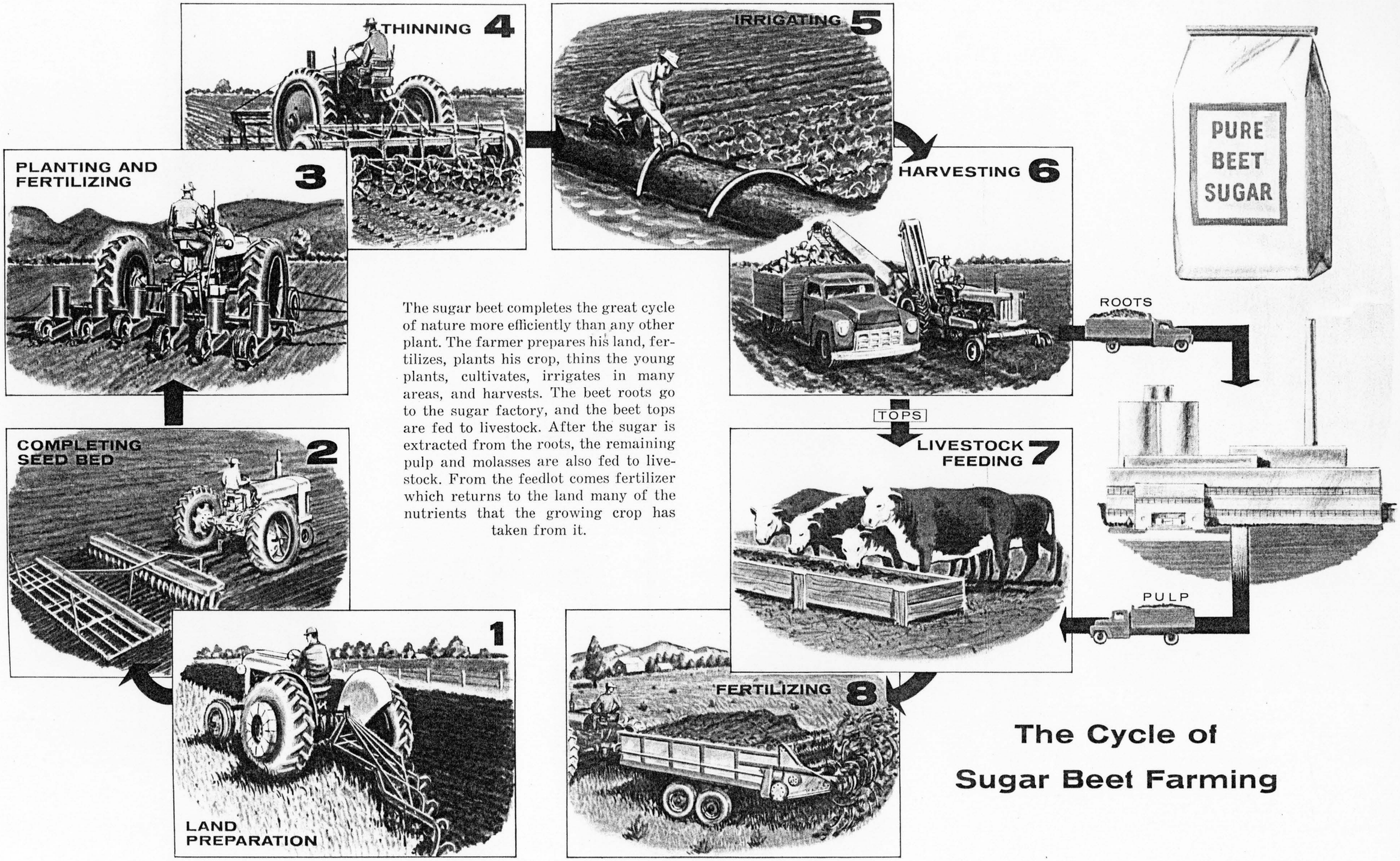
University of California
Berkeley, California

United States Department of Agriculture
Washington, D.C.



THE SUGAR BEET ROOT

This picture illustrates one reason why the sugar beet is ideal for planting in rotation with shallow-rooted crops. The tap root of the sugar beet extends as much as six to seven feet deep, and smaller roots reach out in all directions, aerating the soil and drawing nutrients from levels not required by other crops. When the beet is pulled from the ground at harvest, the lower part of the tap root and the tiny rootlets remain, decaying and adding fertility and humus to the soil. Notice that beet roots extend more than twice the depth of the yardstick next to second beet from left.



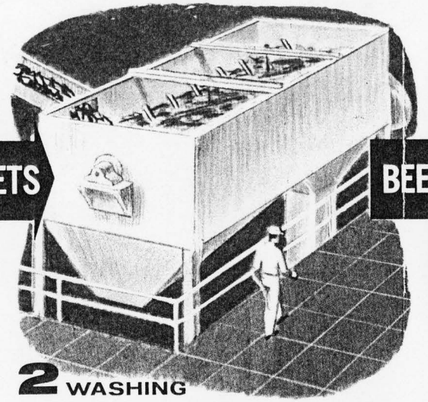
The sugar beet completes the great cycle of nature more efficiently than any other plant. The farmer prepares his land, fertilizes, plants his crop, thins the young plants, cultivates, irrigates in many areas, and harvests. The beet roots go to the sugar factory, and the beet tops are fed to livestock. After the sugar is extracted from the roots, the remaining pulp and molasses are also fed to livestock. From the feedlot comes fertilizer which returns to the land many of the nutrients that the growing crop has taken from it.

The Cycle of Sugar Beet Farming

FROM SUGAR BEET TO BEET SUGAR—BASIC STEPS IN PROCESSING

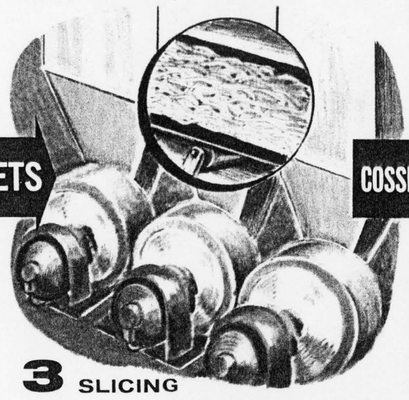
1 THE SUGAR BEET

BEETS



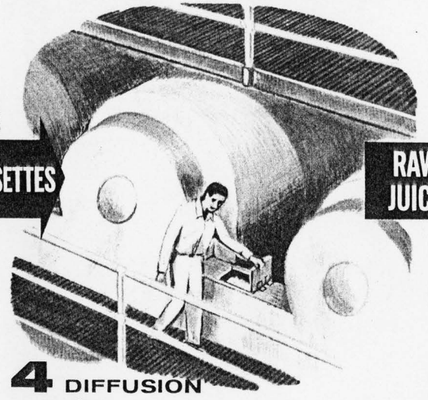
2 WASHING

BEETS



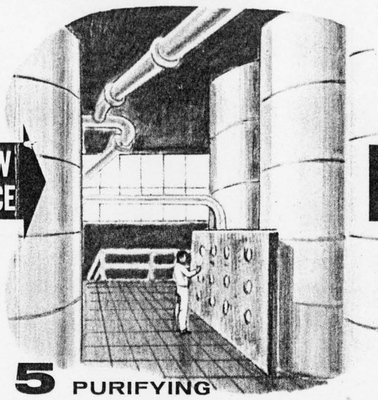
3 SLICING

COSSETTES



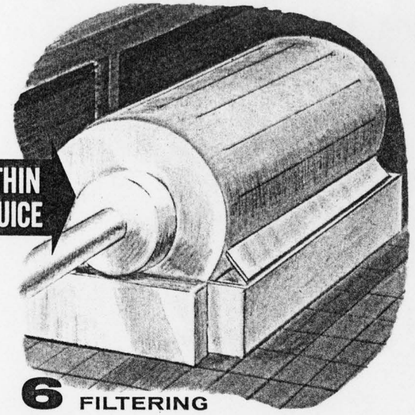
4 DIFFUSION

RAW JUICE



5 PURIFYING

THIN JUICE



6 FILTERING

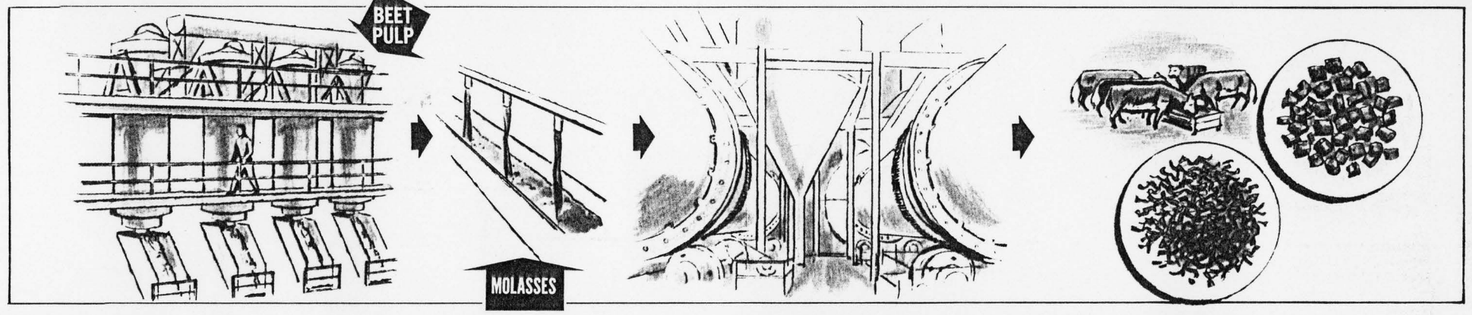
ILLUSTRATED PROCESSING STEPS

1. Sugar beets arrive at the factory without crown and green leaves. **2.** In preparation for processing, beets are washed thoroughly. **3.** Then, razor-sharp knives slice the beets into thin strips called cossettes. **4.** Through diffusion — a process which involves soaking the cossettes in hot water — the sugar is removed in liquid form called raw juice.

(With sugar removed, the cossettes are called beet pulp. This may be fed to livestock while wet, or moisture may be removed by pressure and heat. Often beet molasses, from a later stage in the sugar processing, is added to the pulp before drying. In dried form, sugar beet pulp is also a highly desirable livestock feed.)

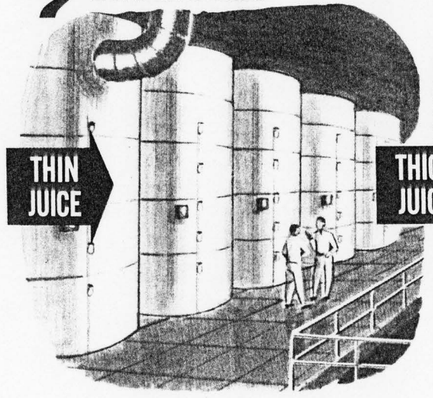
5. The raw juice leaves the diffuser and goes through various purifying processes. Milk of lime and carbon dioxide gas precipitate (solidify) non-sugar substances in the juice. **6.** Filtering removes the solidified particles and thus removes non-sugars. Carbonating and filtering are repeated.

7. The purified juice is thickened by evaporating excess moisture. **8.** More filtering takes place. **9.** Crystals are formed in the thick juice by boiling in huge vacuum "pans" and seeding with pulverized sugar. **10.** Crystals are separated from the remaining liquid by whirling in high-speed centrifuges. (The liquid — molasses — is used for by-products, including livestock feed.) **11.** Crystals are dried and sorted according to size. **12.** The pure sugar then is packaged or stored in large bins. Pure beet sugar is available in many sizes of containers, and also in bulk and liquid form.



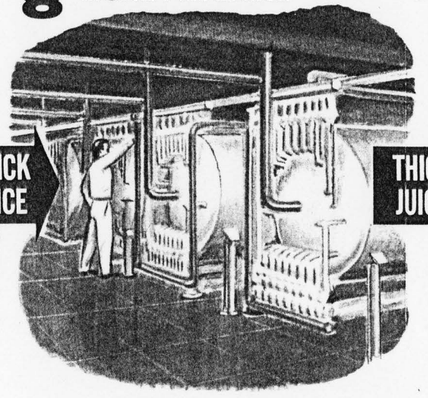
7 EVAPORATING

THIN JUICE



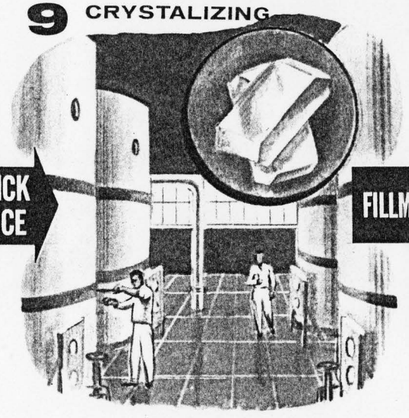
8 MORE FILTERING

THICK JUICE



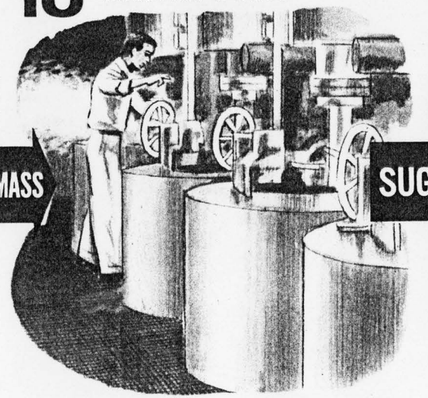
9 CRYSTALIZING

THICK JUICE



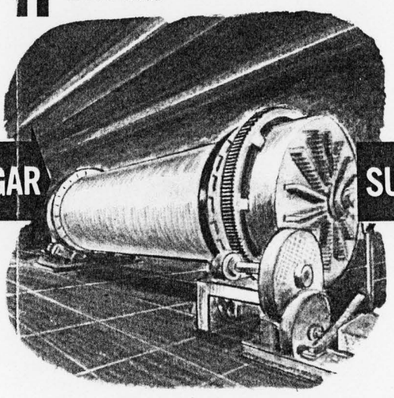
10 CENTRIFUGING

FILLMASS



11 DRYING

SUGAR

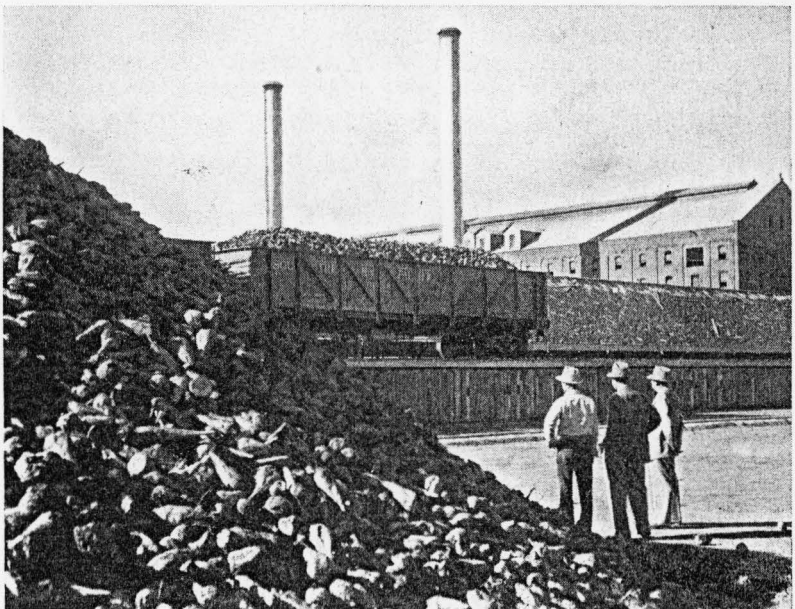


12 PACKAGING

SUGAR

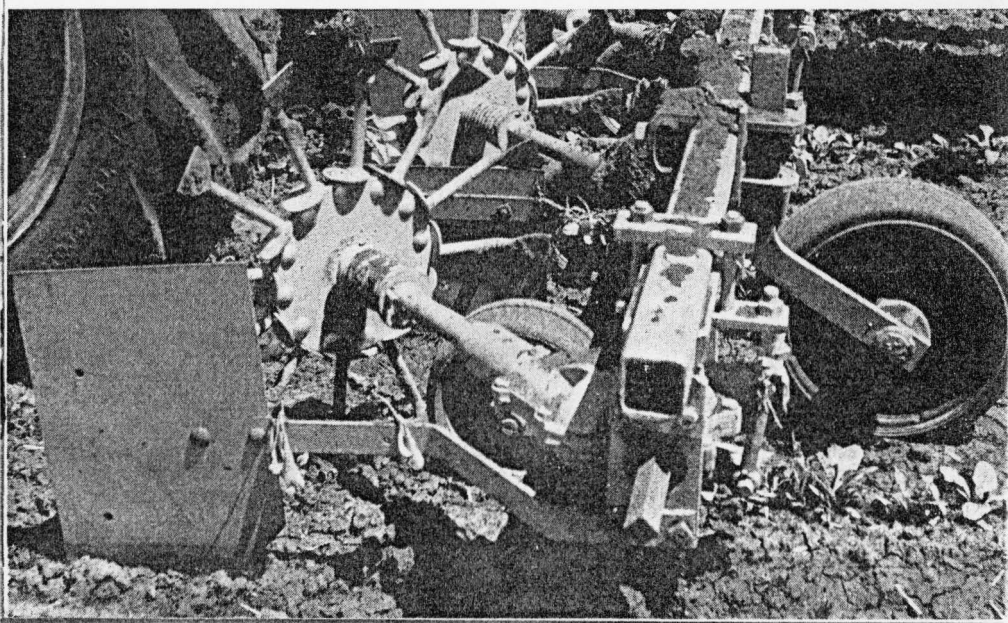
UNLOADING SUGAR BEETS AT THE FACTORY

During harvest, sugar beets arrive continuously at the factory — some by truck directly from nearby farms and some by long trains from receiving stations at outlying points. After being weighed, each truck is unloaded swiftly (*above*) and the beets are piled to await processing. When hopper-type railroad cars are used (*below*), the cars may be unloaded directly into a flume which floats the beets into the processing plant.



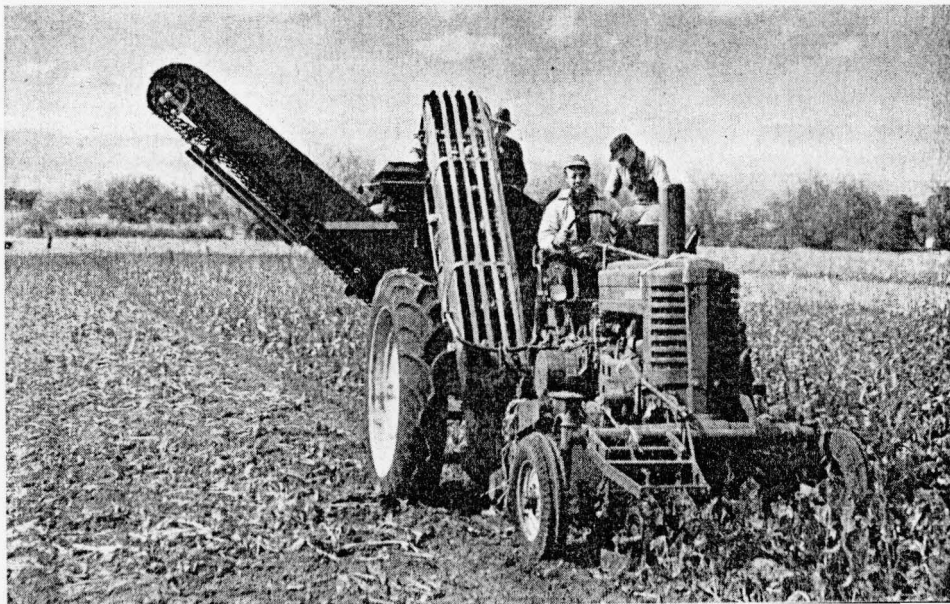
MECHANICAL THINNERS

Scientific advancements, both in seeds and machines, now permit mechanical thinning of young sugar beet plants and also removal of weeds in the rows — jobs formerly performed by hand. Photos here show two makes of machines with revolving blades. Cultivating between plants with mechanical equipment that moves down the row is a comparatively recent development in America's agricultural history.



MECHANICAL SUGAR BEET HARVESTERS

Farm implement companies today manufacture many types of sugar beet harvesters. One kind, a refinement of the first beet harvester developed, features huge spiked wheels (*above*). As the machine moves down the rows of beets, plow blades under the wheels loosen the beets, which then are impaled on the spikes and lifted from the ground. Leafy tops are sliced off automatically before the beets are loaded into a truck. Examples of other kinds of harvesters are shown *below* and on the next page.



MACHINES IN SUGAR BEET FIELDS

American sugar beet farmers speedily adopted efficient mechanical methods of harvesting the crop as soon as satisfactory machines were developed. Often neighboring farmers assist one another with the harvest, and two mechanical harvesters in a single field are a common sight (*above*). Another kind of beet harvester is shown *below*. Although they differ mechanically, all harvesters have one thing in common: they have greatly increased the efficiency of the American sugar beet grower.