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THE SUGAR CANE INDUSTRY IN THE VIRGIN ISLANDS

I. Cultivation

When European navigators sailed to the New World in the 1500s, they brought sugar cane with them. A century later, the crop was being cultivated throughout the West Indies, Central America, and southernmost North America. Sugar cane (Succhinarum officinaum) is a grassy plant which reaches 14 feet in height and 6 inches or more in circumference. Its jointed stem, filled with juice, has several small silky ears at its top. While many cane varieties have been cultivated around the world, West Indian planters preferred "Otaheite" cane, which matured earlier (10 months vs. 12-14 months for other strains) and yielded a greater amount of marketable cane. [1]

The Caribbean islands, with warm days and average annual rainfalls of 45 inches or so, and with fertile, mineral-rich soils, seemed ideal for sugar cane cultivation. Planters formed both lowland and highland estates. Lowland estates were easier to plant, yet their crops were often washed away after heavy rains or blown down in strong winds. Highland estates, on the other hand, kept somewhat better and matured crops earlier, but were often quite inaccessible. [2]

Whichever locality a planter selected, he needed to clear dense tropical vegetation before planting could commence. This long and arduous task often rewarded a planter since mahogany and other hardwoods, when sold in Europe, could easily meet the cost of the plantation. [3] After clearing his land, a planter usually divided it into squares of 8 to 10 acres, each square separated by a path on which cattle fodder was often grown. [4] Prior to planting, each square was further marked into much smaller squares, 4 feet by 4 feet. Each sub-square contained a central hole surrounded by a low dirt wall. "Holing," as this process was termed, was perhaps the hardest step in planting sugar cane, and it consumed much time and required all available labor. [5]

Fresh sugar cane cuttings from the cane tops were used in planting. Two cuttings were placed in each hole after it had been manured and treated with soil-enriching agents such as lime, old cane trash, and vegetal matter. [6] Leaving two walls for furrows, workers replaced the dirt in a hole. Planters utilized separate acreage for "ratoon cane," the cuttings from previously cultivated cane plants. These ratoons matured earlier and could be planted several times, but they yielded much less cane-juice than sugar cane grown from fresh cuttings. [7]

The planting season normally lasted from October to January, after the heaviest rains and the hurricane season had passed. Sugar cane plants would then be ready for harvesting in late December, and sugar manufacturing could be completed by late spring in time for the first ships arriving from Europe. [8] Many elements affected a crop's growth. Insects, rodents, cane diseases, droughts, and excessive rainfalls were not uncommon problems for West Indian planters. The canes required occasional weeding and hoeing during their rapid growth. Planters spent time repairing machinery, maintaining factories and residence buildings, and cultivating other crops during cane-growing season.

Harvesting sugar cane was difficult and required great strength, since the ripened cane-stems "were hard as glass." [9] Workers using machetes cut each cane near its base and sheared off the cane-top for future cultivation. The leaves were trimmed away, often to be used as fuel during the sugar-manufacturing process. [10] Mules or oxen-drawn carts transported bundles of cane to the sugar-mills for crushing.

II. A) Sugar-Manufacturing: Mills

Sugar planters relied on mills containing three rollers to express cane juice from the stalks. Water, animals, wind, and steam were the primary sources of motive power for such mills, but only the last three types found wide use in the Virgin Islands.

Animal-mills crushed cane until the mid-1700s. A wide circular stone or earthen wall, upon which the animals (mule, cattle, or sometimes horses) walked, surrounded a level area. In the center of this area the three mill rollers were placed on vertical axis, and an axle attached to the center roller held two long arms to which the animals were hitched. The motion of the walking animals propelled the middle roller, and in turn the flanking rollers, through a series of cogwheels. [11] While one group of slaves fed cane stalks through one side of the rollers, slaves on the opposite side guided the stalks around and through the other side until the cane was fully crushed. [12] Animal mills at best produced only eight or nine hogsheads of cane-juice per week, as the animals soon tired from the great exertion required to drive the mill and crush the solid cane stalks. [13]

The first windmills appeared in the Virgin Islands about 1740. Within a few decades they had largely replaced animal mills on St. Croix; the change to wind-power took somewhat longer on St. John. [14] Employing a similar system of three vertical rollers, an axle, and cogwheels, windmills provided a more constant and forceful source of power than animals and offered increased cane-juice output. A dome atop the stone tower in the windmill housed the axle linked to the four canvas sails,

and the entire dome assembly could be turned, using a long pole reaching to the ground, to face the sails directly into the wind. [15] Although trade winds swept across the islands with great regularity, calm periods occasionally stilled the windmills. Many planters therefore retained their animal mills as auxiliary crushers should the winds fail.

Steam did not gain prominence as a motive power for sugar cane mills until after the emancipation of slaves throughout the Danish West Indies in 1848. [16] Once it was adopted, steam power revolutionized not only the cane-crushing process but also the entire sugar industry. The cane-crushing process became much faster and more efficient. A steam mill, if carefully adjusted and maintained, could extract 75 percent or more of the juice from a cane stalk. [17] This increased capacity required new sugar-making technologies to keep up with the great out-put of cane-juice, which had to be processed immediately after it was expressed. Improved coppers and clariflers, and new apparatus such as precipitators, vacuum pans, condensers, and granulators, using exhaust steam from the engine, replaced the traditional assemblage. [18]

Steam power also altered traditional estate management patterns. Many planters, unwilling or unable to purchase expensive steam mills, [19] entered cooperative agreements. Under these agreements, they harvested their sugar cane and then delivered it to the steam-mill of another planter. This eventually led, on St. Croix, to the construction of several large cane-crushing stations from which cane-juice was piped to a central sugar factory. [20]

II. B) Sugar-Manufacturing: Pre-Steam Techniques

Estate owners planning to construct a sugar factory generally had two design options from which to choose. Pere Labat's 1724 [21] plan featured a rectangular building with coppers lining one side wall, and with the remaining floor space arranged into four sections - two containing molasses cisterns and one each for barrel storage and for draining molasses from the processed cane-juice. Oxholm's 1797 [22] "ideal T-shape" factory layout in corporated two separate areas. The T-stem served as the sugar-works room; it housed coppers, clarifiers, and cooling pans. The T-head functioned as the rum and storage room. Here, molasses were drained; rum was cooled in a cistern after passing into the building from the still and doubler; and sugar hogsheads and rum casks were held for shipping. In either case, "the boiling-house was specially laid out so that a single pair of eyes - the overseer's - could survey all the coppers from the same place." [23] Generally, however, West Indies planters seem to have prefered Oxholm's arrangement to Labat's.

From a receiver beneath the animal mill or windmill, cane-juice flowed by gravity into the boiling-house or sugar factory through a lead-lined

trough. [24] It was important to process this juice quickly, for once extracted from the cane stalk, it began to ferment and sour. The juice first passed into a pan known as the clarifier, which held 300 to 400 gallons of fluid. [25] A fire beneath the clarifier heated the juice nearly to boiling, and a temper such as lime powder was added. As the juice heated, impurities rose to its surface forming a scum. The juice was clarified for nearly an hour, after which the impurities were skimmed off. The clarifier was elevated, and the juice, after draining through a petcock, ran down through a gutter into the first copper. [26]

There were generally four coppers or boiling pans, "built into a solid long shelf of mortar" [27] with a furnace beneath each pan. A long flue leading to the chimney serviced each furnace and carried away the hot flow-gases. Dry cane trash or "bagasse" was usually employed as fuel to produce a "strong, and above all an even fire," but some wealthier planters used coal for fuel. [28]

Hot cane-juice entered the largest copper, called the "Grand Copper," where it was boiled and skimmed. This boiling process reduced the juice's volume, and the second copper, into which the juice was ladled, was of smaller size than the Grand. Tempers were again added to further cleanse the cane-juice of impurities. The process continued in the third and fourth coppers. This fourth and smallest copper was known as the "Teache." The head-boiler, usually a slave, tended the Teache and had the responsibility of determining when the cane-juice was ready to "strike." Striking was "the crucial point at which the syrupy mass would best cystalize into good graining sugar when cool". [29] The head-boiler "was the artist, and the quality of the sugar depended on him." [30] If it were struck too soon or too late, the entire batch of cane-juice might be lost. Various methods were used to determine proper time for striking. Some boilers tested the juice in cold water for coagulation. [31] Others felt that the surest way "was to dip the forefinger and thumb into the boiling liquor and see whether it would make a thread between them." [32] Years of practice and observation produced the best head-boilers, who often enjoyed special treatment from the master.

When the head-boiler signalled "strike," a crew of workers ladled the boiling cane-juice mass into a wooden trough leading to one of the cooling pans (usually six) on the other side of the room. This trough was portable, so it could be moved to the next cooling-pan when the first was filled. [33] Each pan was a shallow wooden receptacle measuring about seven feet long and six feet wide, holding one hogshead (1500 pounds) of sugar. The sugar cooled and formed a crystalline mass, [34] which was transferred to hogsheads.

The hogsheads, each holding a cooled sugar mass, were "suspended on racks over a cistern built to hold molasses." [35] The molasses drained

through papaya stalks plugging eight or ten holes in the bottom of each hogshead. This process, known as "potting," lasted about three weeks, "after which each hogshead, filled with moist brown muscovado sugar, was ready for shipping. [36]

Many surprises often greeted the sugar planter, making the industry a rather fickle venture. Sugar which seemed fine in the curing-house hogsheads would sometimes drain during the voyage back to Europe and come out bad. Other hogsheads "which had received special care and experiment in planting or boiling would turn out just like the rest." [37] Conversely, a poor-looking batch might well "mend on the voyage." Oxholm, discussing windmills and sugar production output, wrote:

> Twelve hundred quarts of juice give about 200-300 pounds of sugar, according to how ripe and fresh the juice is. On a good day's harvest, using two coppers, you can obtain three to four barrels or 4000 to 6000 pounds of sugar. [38]

II. C) Sugar Production and Rum-Making

The by-products of sugar production could be used to make rum. The rum-making process was simple, and the ingredients used in the "mash," the mixture from which rum was distilled, could be varied to suit the planter's taste and preference.

In its most basic form, mash was composed by mixing skimmings from the cane-juice boiling process; the water used in cooling and cleaning the coppers; and molasses. Set aside in barrels that were stirred daily, this mixture fermented in seven to ten days. [39] Another type of mash was formed from "a mixture of about one part molasses to five parts water," occasionally supplemented with "cush-cush, the fine bagasse (cane trash) particles left in the strainer when the cane-juice ran down from the mill," and lime or begetable ash. This too was set aside until fermented. [40] The finest quality rum was made of mash consisting solely of "pure cane-juice direct from the mill, requiring no special additives to start fermentation, as the juice contained wild yeast." [41]

Mash ran from the barrels or "butts" through a pipe to the pot still located outside the rum rooms. A furnace beneath the still heated the fermented mash, and the resultant vapors passed through a gooseneck pipe on top of the still into the retort or doubler. The doubler was already "filled to one-fourth its capacity with low wine, a weak low-proof rum taken off at the beginning and end of every distillation." [42] The hot vapors from the still heated the low wine, causing it to boil, which "greatly strengthened the proof or alcoholic strength." [43]

Vapors from the doubler passed through a coiled pipe or "worm" contained in a cistern filled with cold water. The vapors condensed into rum as they passed through the worm, and the rum was collected in a receiving tank for barreling. The first five gallons of this condensed rum were drawn off as "low wine." [44] Pot still rum averaged 120 to 140 proof, and anything under 108 proof was considered inferior and was used for low wine. [45] This rum was a colorless liquid that planters preferred to golden rum, and they lined their rum barrels with wax to prevent the liquor from yellowing while aging. [46, 47]

II. D) Sugar Manufacturing: Steam Technologies

The shift to steam mills forced, in most cases, a comparable improvement of existing boiling-house technology. Steam mills produced such an increased amount of cane-juice, which had to be quickly processed before fermentation commenced, that to make sugar in the old style would be wasteful. As one author notes:

> No capitalist in settling a fine estate ... would, however, be doing justice to the property, were he to neglect furnishing the manufactory with the machinery best calculated to produce the largest amount of sugar at the cheapest rate. [48]

Designs for sugar factories were revised to accommodate the new steam apparatus. Steam exhaust from the engine could heat the boiling-house equipment, and steam-driven pumps would eliminate the need for the many gravity-flow troughs in the factory. Oxholm's T-shaped model was modified to incorporate a steam engine, mill, and boiler in the sugar-works room. [29] An "improved plan of a manufactory, worked by steam" consisted of a cross-shaped building whose vertical arms housed the steam engine and mill, and the rum-making facilities, and whose horizontal arms housed the curing-house and cane-juice boiling assemblage. [50]

Harvested cane stalks, no more than five feet in length, were fed into the mill and the heavy rollers expressed the juice. The juice then passed from the mill through four brass-wire strainers which removed "a large portion of those substances mechanically suspended in it." [51] As for the cane trash, to use it for fuel was "one of the greatest causes of mischief," [52] because drying and storing it wasted precious time and effort.

The strained cane-juice flowed into the clarifier where, as in the old manner, it was heated as the pan filled. Quick-lime cream was mixed with the juice, and after the thick crust of impurities formed on the surface, the fire was removed and the juice cooled for about ten minutes. The juice then passed through a finely-grained vegetable char-

coal filter and into the precipitator. This clarifying process was known as "defecation," or "the complete separation of all extraneous matter from the cane-juice, so as to bring it, as nearly as possible, to the state of sugar and water alone." [53]

Precipitators continued the defecation process, as the cane-juice was boiled and skimmed for another ten minutes. Workers added "Howard's finings," a cream-like temper made from lime and boiling water. The juice as stirred, boiled for a few more minutes, and finally drawn off through charcoal filters into a "fining cistern" where it settled and cooled for about six hours. Steam serviced both the clarifier and the precipitator, and each pan held approximately 550 gallons. [54]

Passing again through a series of charcoal filters for decolorization, the cane-juice was pumped to the evaporators. The evaporators, of which there were usually five, replaced the coppers. By means of steam flowing through coils embedded in the pan, water in the cane-juice evaporated "so as to leave the sugar in the condition of a fine white syrup which will crystalize wholly and well." [55] Piping and slide valves enabled the syrup to flow from one evaporator to the next. [56] By the time "skipping" had been reached (the proper temperature for discharging syrup from the teache), the syrup was three parts sugar to one part water. [57]

At this stage in the sugar-making process, a planter had various options as to how to further concentrate the syrup. Depending on the apparatus in his factory, a planter might employ vacuum pans, "Wetzal pans," or "Kneller's Process." Vacuum pans, first introduced in the mid-1830s, [58] were used to take advantage of the fact that "liquids boil at a much lower temperature when relieved of the pressure of the atmosphere." [59] Serviced by exhaust steam, a vacuum pan rarely burned the syrup, which was heated to about 160 degrees Fahrenheit, and it could concentrate five to seven tons of syrup per day. "Wetzal pans" concentrated the syrup by means of a rotating drum, partially immersed in the fluid. As the drum rotated, it picked up syrup and exposed it to the air. While these "simple but effacious devices" were cheaper than vacuum pans, their agitating motion tended to damage the sugar grains. [60] Under "Kneller's Process," cold dry air was forced through tubes embedded in a pan; the air, "rising through the body of the liquid," removed a great amount of water vapor while keeping a syrup at a very low temperature. [61]

The final step in the modernized sugar-making process consisted of granulation or crystalization. A single cooling vessel replaced the numerous casks and hogsheads. It had sloped walls and a channel across the bottom. Twelve to fifteen holes in the bottom (one inch in diameter) were plugged while the syrup cooled and crystalized, then the holes were opened for drainage. A process called "liquoring" was often performed,

in which workers poured a thick solution of pure sugar over the crystals to cleanse them. The crystals, after drying in the sun, were then packed into wooden boxes or hogsheads. [62] The rum-making process remained unchanged following the introduction of steam technology. It continued to employ a still, a retort or doubler (some planters used two doublers) and a worm coil in a cooling cistern. [63]

III. The Sugar Industry in the Danish West Indies

A) St. Croix

Columbus carried sugar cane with him on his second voyage to the New World in 1493 when he discovered St. Croix, but there was no sugar industry on the island until the mid-seventeenth century. Dutch, English, and French settlements existed on the island in the mid-1600s, and the French by 1670 operated some 90 estates in sugar cultivation. [64] This early effort collapsed in the next years due to droughts and supply shortages, and by 1687 only twelve sugar estates were listed on census records. [65] The French and Dutch colonists abondoned St. Croix in the 1690s, leaving behind only a few English squatters.

The Danish West India-Guinea Company, which had been formed in Copenhagen in 1671 "to share in the colonial and commercial enterprise of the seventeenth century," [66] purchased St. Croix from the French in 1733, and two years later company representatives began surveying the island. St. Croix was divided into 9 quarters, [67] each quarter subdivided as nearly as possible into rectangular tracts known as "matricula." One matriculum averaged 2000 by 3000 Danish feet, or 150 Danish acres. [68] Each tract was sold or leased to settlers, who cleared their estate for cultivation and constructed house, factories, and other facilities. By 1754, according to a map of the island, 94 animal mills and 20 windmills were being used to grind sugar cane. [69]

An era of prosperity for sugar and rum production occurred from 1750 to about 1815. Some 334,000 tons of sugar were exported from St. Croix between 1777 and 1807, along with nearly 30 million gallons of rum - including 4,308,922 gallons in 1789 alone. [70] Another indication of this prosperity came in the numbers of slaves imported. When Denmark outlawed the slave trade in its colonies in 1803, the St. Croix population stood at nearly 30,000 people, of which almost 27,000 were slaves. [71] Unfortunately for the planters, this prosperity also carried with it the curse of rising operating expenses. In 1750 a planter spent approximately 17,000 rigsdalus for his estate - its purchase price, the costs for sugar-manufacturing apparatus, and the fees for slaves contributing to that total. [72] These expenses had risen dramatically in fifty years

to over 70,000 rigsdalus (or to over 300,000 Spanish Pieces of Eight, which had largely replaced Danish currency by this time). [73] Despite these prices, however, the number of estates continued to rise, peaking in 1796 with 175 plantations containing 144 animal mills and 114 windmills. [74]

The trend towards opulence and prosperity reversed in the late 1810s, initiating a slump which would last until the early 20th century. Without the importation of new slaves after 1803, the labor market tightened and slave prices soared. European wars and depressions affected overseas sugar markets and sharply lowered prices in the 1820s. Many nations, including the United States, imposed heavy duties on foreign sugars to protect their own industries. Natural disasters, such as frequent droughts, an 1819 hurricane, and a series of epidemics, plagued St. Croix. [75]

The harshest blow to the St. Croix sugar industry came in the 1830s from the recently-founded beet sugar industry. Planters in the colder American and European climates found that they could successfully raise sugar beets, from which sugar could be obtained more easily and cheaply than from cane. The Danish Government had changed the Danish West Indies sugar export rules in 1833 and "abolished Copenhagen's 66-year-old monopoly on the re-exporting of raw sugar which had come in from the island," but several nations now imposed tariffs to protect their own beet sugar industry from sugar cane competition. [76]

A possible stimulus for the slumping St. Croix sugar industry was steam power, first introduced for milling in 1814 at Estate Hogansborg. This first steam mill, however, was "inclined to be broken down as often as it was running." [77] Nevertheless, steam mills survived this shaky start, and in 1845 one visitor to St. Croix noted that, in contrast to windmills calmed by shifting trade winds, the three steam-powered estates on the island operated regardless of the weather. [78]

An event in 1848 gave dramatic impetus to the adoption of steam. Following an insurrection, the Danish Governor emancipated all the slaves in the Danish West Indies. Overnight, planters lost their entire labor force. A Labor Act passed the following year required the planters to provide wages and other benefits for their workers. Steam power gave planters the opportunity to operate a sugar factory using only 15 men, in a period when every expense mattered greatly. [79] There were 61 steam mills on St. Croix by 1857 as more and more planters - those who could afford it - shifted from wind to steam powers. [80, 81]

Steam, however, did not provide the expected reversal of ill fortunes. Sugar production levels on St. Croix continued to decline to about half of what they had been during the industry's heyday. Rum out-

put fell by nearly 30 percent, while the production of molasses dropped from 922,338 gallons in 1845 to only 7,537 gallons in 1854. [82] Associated with the lowering production rates was a comparable decline in land values, by as much as 60 percent. [83] Many plnaters went bankrupt and sold or lost their estates. Natural disasters seemed to be the only items to increase; in 1867 alone a tremendous hurricane was followed only a month later by a devastating earthquake. [84]

The opening years of the 1870s sounded the death knoll for many estates. Only 90 plantations remained, and in the hope of boosting their sagging production levels, nearly all of the planters had converted to steam technology - which caused "much duplication of investment and effort." [85] An unusually severe drought caused further hadrships. In 1873 only 29 inches of rain fell in contrast to the average annual level of 46 inches. [86]

A ray of hope appeared in 1874 when the Governor and planters agreed on the necessity of constructing a cooperative Central Sugar Factory on St. Croix. Denmark subsidized the project and construction began in 1876. Equipped with five huge horizontal steam mills, [87] the Central Factory opened in early 1877. Planters harvested their estate's sugar cane crop and transported the bundled cane stalks to the factory for grinding and for sugar manufacturing.

The respite from misfortune for many planters ended abruptly in October 1878 when laborers in Fredericksted, St. Croix, went on a five-day rampage of looting and arson. After order was finally restored, 50 plantations lay in ruins, and in all but eight of these the sugar-works were destroyed. Much machinery in the Central Factory was damaged, and the total estimate of losses on St. Croix ran well over $1,300,000. [88] Many planters simply left their ravaged estates and departed from St. Croix.

The government found it difficult to fund repairs on the Central Factory and instead opted to build several smaller factories. The first of these opened in 1883 at Estate Bethlehem and a second followed at Estate Barren Spot in 1885. At Estate La Grange "a small narrow-gauge railroad was installed ... to haul in the freshly cut canes to the mill." [89] The largest sugar factory of them all opened at Estate Lower Love in 1896 "and in its time it was the most modern factory in the northern Caribbean." [90]

Even under the auspices of a revitalized sugar industry, planters continued to abandon their estates, often in bankruptcy. Sugar prices fell to their lowest level in 1884, and to add insult to injury, Denmark began producing its own beet sugar. [91] Many of the remaining planters switched to the cultivation of crops other than sugar cane, including

cotton, pineapples, and coffee, or to cattle-raising.

The events of the 20th century have been somewhat more beneficial to the St. Croix sugar industry. For a decade after the United States purchased the island from Denmark in 1917, another terrible drought brought sugar clutivation to a virtual standstill. Under President Franklin Roosevelt, however, Federal subsidies were used to establish The Virgin Island Company (VICO) to rejuvenate the sugar industry. The government invested $90,000 in the factory at Estate Bethlehem and thus sugar manufacturing resumed on St. Croix. [92]

III. B) St. Thomas and St. John

Their proximity and close historical association permit St. Thomas and St. John to be considered together. The era of sugar prosperity for these islands began earlier and ended more abruptly than on St. Croix, but the general circumstances for all three islands were much the same.

Although Europeans visited and perhaps dwelled for short periods on St. Thomas in the early and mid-1600s, the Danish West India-Guinea Company, formed in 1671, "took possession of St. Thomas as uninhabited" later that year. [93] The first Danish settlers arrived in 1672 and struggled to attain stability for nearly a decade amidst illness and other hardships. Estates were demarcated haphazardly [94] and cultivation consisted primarily of tobacco and cotton. The "want of sufficient laborers" hindered agriculture until the Danish Government ordered all estate-owners to possess a specified number of slaves or pay increased taxes. [95] Although the situation somewhat improved, sugar cultivation continued to lag until in 1685 a decree ordered the immediate cultivation of sugar where possible or estates would be confiscated. [96] Despite this order, records from 1691 indicate that of the 101 estates on St. Thomas, only five produced sugar. [97] During the early years of the 18th century, "the most progressive for St. Thomas agriculture," [98] the number of estates grew to 164 by 1720 and 177 by 1725.

A critical land shortage on St. Thomas, whose mountainous terrain and poor soil made agriculture difficult at best, forced the Danish West India-Guinea Company to seek expansion elsewhere. Thus in 1718 company representatives ventured to St. John to settle at Coral Bay. The history of prior settlements on St. John had been similar to the situation on St. Thomas: several unsuccessful efforts, the last being the Danish in 1683. English forces had dispersed this settlement and had blocked further colonization since that time. [99]

Danish West India-Guinea Company settlers arrived first and, after surveying St. John and dividing it into districts, [100] occupied the largest and most fertile area on the island, in the Coral Bay district.

The other settlers -- Danish, French Huguenots, and Dutch [101] -- arrived shortly afterward, and despite various provisions "for the proper distribution and settlement of the land... the numerous land disputes which arose between planters were indicative of the haphazard way in which lands ... had been distributed." [102] Sugar and cotton crops were soon in cultivation. While sugar plantations on St. Thomas averaged 60 to 70 acres, those on St. John were somewhat larger, averging 80 to 90 acres. [103]

Sugar production began to decline after 1725 on St. Thomas. The number of estates fell from 63 to 38 by 1754. Pere Labat, visiting the island in the early 1700s, observed that: "[the estates] are small, but well kept. Work is only performed during the day, and in consequence but little sugar is made." [104] Cotton continued to be the preferred crop; it required less acreage, equipment, and labor. In order for sugar cane to be economically desirable, it had to be grown in large quantities, and the small size of the St. Thomas estates made this difficult. The hardier varieties of sugar cane, such as Otaheite, would not be introduced into the West Indies until the late 18th century, and the varieties grown on St. Thomas were quite susceptible to droughts, pests, and cane diseases. Many sugar cane growers on the island abandoned their estates, and if they were not bankrupt, sailed to St. John where some fertile land was still available, or to St. Croix following its initial settlement in 1734. The Danish Crown assumed control over the islands in 1754, and from then on "the inhabitants of St. Thomas had increasingly turned their attention towards trade and away from agriculture." [105] The number of estates declined as the amount of harbor-related commerce increased, and a severe drought in 1789 shut down many of the remaining plantations as "planters ... were constrained to sell some of their slaves to the French and Spanish colonies to prevent starvation." [106]

As was the case on St. Thomas, cotton cultivation attracted more planters than sugar cane. Again, it was a question mainly of expense. Sugar cane planters on St. John were granted tax-free status for seven years, provided that they constructed a mill and a sugar factory on their estate by the end of that time. Despite this tax incentive, the costliness of such a venture deterred many planters from growing sugar cane. [107] There were 48 cotton plantations in 1728 and only 29 sugar plantations. [108] Sugar cultivation in general was more profitable here than on St. Thomas, because the more fertile soil allowed for a larger crop yield.

The year 1733 began on an especially shaky note for St. John planters. A prolonged drought, an insect plague, and a severe hurricane swept the island. Sugar production was crippled, and company estimates of 150 hogsheads far exceeded the actual result of 62. [109] Droughts and other calamities were a fact of life in the West Indies, however, and these fig-

ures would not unduly affect long-range sugar production output. What did have a dramatic effect came as a complete shock to St. John planters when, in November 1733, slaves on the island bagan an insurrection which was not controlled until mid-spring of the following year. After a band of planters and a militia of British soldiers had failed to quell the bloody uprising, it was finally stopped by a French expeditionary force, but not before taking a heavy toll:

> Of the estates, on forty-four the buildings were all destroyed, whilst on forty-eight they had been preserved. The governor's estate had suffered the most. Many planters were of course ruined, and those who found themselves involved in debts, retired to Tortola. [110]

St. John had for the most part recovered by 1739, but at that time its sugar industry commenced on a gradual decline. The number of estates fluctuated slightly as some plantations were abandoned and subsequently consolidated by others. Only 21 estates remained in sugar cultivation in 1754 [111], but this fugure increased to 27 in 1773. [112] Commerce assumed growing importance here as on St. Thomas, especially after the Danish Crown took control of the islands in 1755, and after Frederick V declared St. John a free port in 1764. [113] Oxholm's maps of St. John for 1780 and 1800 [114] reflect an upward trend in the island's sugar industry during this period. The number of sugar mills increased from 22 to 28 (26 animal mills and 2 windmills). [115] Sugar production in 1796 totaled some 850,000 pounds. [116] These figures paled in comparison to those for St. Croix, however, where the era of sugar prosperity was reaching its zenith (e.g., figures for 1796 alone show 11,214 tons of sugar were produced). Many planters on St. John, anxious to improve their sugar fortunes, left for St. Croix.

The factors which transformed the St. Croix era of prosperity into an age of collapse - droughts, competition from the beet sugar industry, shrinking markets for sugar coupled with rapidly falling prices -- produced the same result on St. John and caused a more abrupt end to its brief period of relative stability. One indication of this phenomenon is the acreage under cane cultivation, which declined from 1,863 acres in 1796 to only 843 in 1847. [117] St. John was a "marginal area at best" for sugar cane cultivation due to its small size and rugged terrain, and "it simply could not compete with the areas better favored naturally." [118]

The emancipation of slaves throughout the Danish West Indies in 1848 was undoubtedly the harshest and most crippling blow to what remained of the St. John sugar industry. With the elimination of the labor supply, sugar cultivation was "barely possible" and thus "many of St. John's planters began boarding up their estate houses and returning to Europe." [119] One possible solution to the labor shortage was to convert

the sugar machinery at the factory to steam, as many planters now did on St. Croix. Apparently only two estates on St. John were converted to steam, Adrian (about 1848) and Reef Bay (about 1862). [120, 121] A brief period of renewed interest in cane cultivation occurred towards the end of the 19th century, when the use of Otaheite cane became widespread, but the interest tapered off quickly "as the Java cane failed to generate the high profits many had anticipated." [122] The prominence of the worldwide beet sugar industry, the continued depletion of soil on the island, and an increase of pasture lands for livestock - all brought the sugar industry on St. John to an end in the early 1900s, when Reef Bay, the last active estate, closed. [123] Bay oil and bay rum production then were the principal agricultural operations on St. John.

NOTES

[1]Leonard Wray, The Practical Sugar Planter, (London: Smith, Elder, and Company, 1848).
According to Richard Pares, A West-India Fortune, (London, 1950), p. 110, some planters believed however that Otaheite cane took too much from the soil and produced a poorer grade of sugar than other varieties.

[2]Pares, p. 105.

[3]Florence Lewisohn, St. Croix Under Seven Flags, (Hollywood, Florida, 1970), p. 92.
This task occasionally required a year or more owing to the primitive tools used in the cleaning. (Source hereafter referred to as "St. Croix.")

[4]Steffen Linwald, Sukker og Rum, ("Sugar and Rum"), (Copenhagen, 1967; with English translation), p. 64.
The paths separating the squares "might either be planted with ground fruits or Guinea grass which might be used as cattle fodder."

[5]Ibid.
Linwald notes that "in the hot climate this was regarded as the hardest work and ... while it lasted negroes were given double food rations and a toddy of sugar, water, and rum two or three times a day."

[6]Florence Lewisohn, Divers Information on the Romantic History of St. Croix, (Christiansted, St. Croix: St. Croix Landmarks Society, 1964), p. 14.
Pares, p. 112 refers to this process as "holing." (Source hereafter referred to as "Divers Information.")

[7]Pares, p. 109.
Pares estimates that 1 acre of fresh cane would produce 1 hogshead of sugar, while 1 acre of ratoon would produce only 1/2 to 3/4 hogshead sugar.

[8]Ibid., p. 114.
Planters spent time, between planting and harvesting, in building new structures or maintaining older ones. Pares states (Ibid.) that "some parts of the machinery, whether of a windmill or a cattlemill, could be guarded from hurricanes by taking them down and putting them away" at this time.

[9]Linwald, p. 65. Slaves kept watch on the ripening canes "both day and night" since at this time the stalks were very inflammable.

[10]Ibid.

[11]Linwald, p. 65. Animal mills are often referred to as "horse-," "cattle-,", or "treadmills."

[12]Lewisohn, St. Croix, p. 131. Original reference in Richard Ligon, True and Exact History of Barbados, (London, 1657).

[13]Pares, p. 115.

[14]Isaac Dookhan, A History of the Virgin Islands of the United States, (Epping, Essex, England: Bowher Publishing Company in association with the Caribbean Universities Press, 1974), notes p. 80 that by 1796 there were 119 windmills on the three islands (St. Croix, St. John, St. Thomas), with only four of these on the latter two.

[15]Lewisohn, Divers Information, pp. 29-30.

[16]Linwald, p. 65. Other early steam mills were at Estate Whim (ca. 1824) and Estate Barrenspot (1829).
Lewisohn, St. Croix, p. 124. By 1852, there were 40 in operation.
Dookhan, p. 81. Only two are known from St. John - Estates Reef Bay and Adrian.

[17]Wray, p. 299. Wray offers these figures for steam mills fitted with a second set of rollers. For the standard 3-roller cane crusher typical to the Virgin Islands (e.g., Estates Clifton Hill, Rust-op-Twist, Whim, and Annally on St. Croix, and Reef Bay and Adrian on St. John), the average figures for percentage of cane juice extracted would be 50 to 60 percent. This is still far superior to either animal mills or windmills.

[18]Despite this new and improved technology (or perhaps because of it) steam mills, like their predecessors, often had trouble, as Pares notes: "When [planters] had a little more experience, they found that many things could put a steam-engine ... out of action quite as effectually as a calm would immobilize a windmill." (p. 116).

[19]The bill of sale for a steam mill purchased for Estate Slob in 1854 from the George Fletcher Company, London, lists the following prices: (in pounds; $5 is approximately 1 pound)

a) Steam mill:	£1464.18
b) Freight charge for "Malvina":	£75
c) Dock charge, insurance on machinery:	£31.7
d) Insurance on boiler:	£33.6
	£1604.11 = $8,022.75

(Material furnished by David Hayes, Christiansted, St. Croix)

[20]Lewisohn, Divers Information, p. 31.

[21]Pere Jean-Baptiste Labat, Voyages aux Iles Francaise de Amerique, (paris: Chez G. Cavalier, 1742, 8 vols.). Illustration of factory plan (Volume I, p. 296) appears in Lewisohn, Divers Information, p. 24.

[22]Peter Lothamis Oxholm, De Danshe Vestindishe Øeis Tilstand i henscende til Population, Culture og Finence-Forfatning, (Copenhagen: John Schultz, 1797). An example of such a design may be found in the HAER drawings for Estate Reef Bay on St. John and the design is further described in the accompanying report.

[23]Pares, p. 118.

[24]Linwald, p. 66.

[25]Lewisohn, Divers Information, p. 33. In smaller or more primitive factories the cane-juice went directly to the first copper (e.g., Estate Reef Bay on St. John; see note 22.

[26]Lewisohn, St. Croix, p. 132.

[27]Ibid. This shelf, or "boiling bench," is excellently preserved in the sugar factory at Estate Reef Bay, St. John (see note 22).

[28]Pares, p. 117.

[29]Lewisohn, St. Croix, p. 133.

[30]Pares, p. 118.

[31]Lewisohn, Divers Information, p. 34.

[32]Pares, p. 117. It should be emphasized here that of near-equal importance with striking was the maintenance of cleanliness in the factory. As Pares observes, "All the gutters and coppers must, of course, be kept scrupulously clean, for nothing soured the liquor or impaired the sugar as surely as uncleanliness." (Ibid.)

Wray, p. 330. Wray suggested that factories employ "a boy, whose duty shall consist in cleaning the mill-bed, juice-gutters, and strainers" lest the juice sour or spoil due to uncleanliness.

[33]Lewisohn, St. Croix, p. 133.

[34]At this point, according to Lewisohn (Divers Information, p. 34), some planters "clayed" their sugar. "The sugar and molasses mass from the cooler was poured into conical pots or pans, suspended points downward with a hole in the point. This hole was kept plugged for 12 hours during the cooling, then opened and the molasses drained out for another 12 to 24 hours. Then a mixture of clay was spread on top the sugar; some water [was] added to seep down through the clay to carry off more molasses. This left a pure, white sugar."

[35]Lewisohn, St. Croix, p. 133. At Reef Bay this "cistern" consisted simply of three coppers embedded in the factory floor. (See note 22.)

[36]Lewisohn, Divers Information, p. 34.

[37]Pares, p. 117.

[38]Quoted in Linwald, p. 66. For original source see note 22.

[39]Lewisohn, Divers Information, pp. 35-36.

[40]Ibid.

[41]Ibid., p. 36. This was the process used in later years (post 1918) at Estate Clifton Hill, St. Croix, when the estate operated solely as a rum distillary. Consult further the HAER drawings and accompanying report for "Estate Clifton Hill."

[42]Lewisohn, St. Croix, p. 135. On some smaller estates this process was eliminated and the entire boiling routine occurred in the still (e.g., Estate Reef Bay, St. John; see note 22).

[43]Ibid.

[44]Lewisohn, Divers Information, p. 37.

[45]Ibid.

[46]Lewisohn, St. Croix, pp. 135, 220. See also HAER "Estate Clifton Hill" report (note 41 above).

[47]Linwald (p. 67) quotes the 1780 "Aalborg and Juttand Intellegincer" regarding another rum product, "kill devil:"

> From the scum removed when the sugar is being boiled and the molasses, rum is distilled which while it is still young is known as kill devil (because it has killed many, especially new arrivals, who drink it immoderately) and it is very intoxicating and unhealthy. However when it has matured for a

for a year or more it loses this harmful quality and ... is a serviceable medicine.

[48]Wray, p. 309.

[49]See, for example, plate VIII in Wray, "Plan of mill, boiling, curing, and distil houses." (Illustration copy in HAER files.) Example of factory designs incorporating steam into the basic Oxholm plan may be seen in the HAER drawings and accompanying reports for "Estate Clifton Hill," St. Croix, and "Estate Reef Bay," St. John.

[50]See plate IX in Wray. Reconnaissance of existing steam mills and factories in the Virgin Islands [HAER Virgin Islands Record, "Estate Clifton Hill," "Estate Rust-op-Twist" on St. Croix and "Estate Reef Bay," St. John, plus on-site examinations of Estate Annally (St. Croix) and Estate Adrian (St. John)] indicate no factories there were designed in this fashion.

[51]Wray, p. 354.

[52]Ibid., pp. 52-53.

[53]Ibid., p. 353.

[54]Ibid., p. 303.

[55]Ibid., p. 353. The evaporators had the following capacities:

a) first evaporator: 550 gallons
b) second evaporator: 450 gallons
c) third evaporator: 350 gallons
d) second teache: 200 gallons
e) teache: 150 gallons
(p. 303)

[56]Ibid., p. 306. "These pans are worked as follows: the steam being let into the steam-main from the boilers, is let into the worms of the pans by opening the valve (so that either pan can have the steam let into its worm, or shut off, without in any way interfering with the other pans), and passing through the worm, enters the double bottom of the pan, from whence it is discharged, as condensed water, through the escape-valves in the condensed water-main."

[57]Ibid., p. 366.

[58]Linwald, p. 71.

[59]Wray, p. 319. In open pans the temperature for boiling the syrup was about 231°F.

[60]Ibid., p. 301, pp. 368-369.

[61]Ibid, p. 369. Wray states this process was seldom used.

[62]Ibid., p. 373. Commenting on existing pre-steam techniques for granulation, Wray observes:

> The coolers in their present form are peculiarly well-adapted to counteract the objects the planter had in view; and the casks are altogether so barbarous, that it is wonderful any set of intelligent men can persist their use. (p. 377)

[63]Information regarding rum-distilling and steam may be found in Wray pp. 392-413.

[64]Lewisohn, St. Croix, p. 65. The information is based upon the LaPointe Map of St. Croix dated 1671, which is at the Royal Library in Copenhagen. One English sugar plantation is indicated.

[65]Ibid., p. 71. The precarious states of the French colony on St. Croix, observes Lewisohn, was due to the present warlike state of relations between the French and other European settlers in the Caribbean especially the English.

[66]Knox, p. 47.

[67]The nine quarters were: Northside A, Northside B., East End A, East End B, West End, King's Quarter, Prince's Quarter, Queen's Quarter, and Company Quarter. The task of surveying and land parceling lasted until 1754. As Dookhan states (p. 75), "St. Croix benefited from the experience of St. Thomas and St. John (where lands had been improperly surveyed and distributed) as shown in the systematic way the land was divided prior to distribution."

[68]Linwald, p. 74.

[69]This is the "Beck Map," dated 1754, a reproduction of which is in the St. Thomas Public Library, Charlotte Amalie, St. Thomas. Figures listed are from Lewisohn, St. Croix, p. 106.

[70]Longfield Smith, Sugar Cane in St. Croix, (St. Croix: Agricultural Experiment Station, 1920, Bulletin no. 2), p. 5, table "Quantity of sugar and rum exported from St. Croix during the period 1777 to 1807, inclusive."

[71]Lewisohn, St. Croix, p. 206.

[72]Lewisohn, Divers Information, p. 25.

[73]Figures for one estate, "Carlton," from 1803, reveal the following expenses: (in Pieces of Eight)

a) "600 acres of cane land of which there is 322 acres in cane, sprouts at 300 p.s. per acre, 8 acres in yams. The remaining 270 acres in Fallow and Negro grounds --- 180,000
b) 100 acres pasture land at Lands point adjoining the Sea Computer at 100 acres more or less at 150 p.s. per acre --- 15,000
c) A stone Windmill, with Stocks and points --- 10,000
d) A Cattlemill compleat --- 7,880
e) Boiling house with two setts of coppers the one Sett of Furnaces, 4 to each Sett, curing house, to cure 70 Hhds [hogsheads] of Sugar, Still house with 45 butts that contains 10,000 Gallons, 3 Stills that contains 750 Gallons with caps and worms, and stone cistern --- 25,000
f) Black Smithe, Shop, with necessaries --- 800
g) Negroes --- 82,100
h) Overseer house, with 3 rooms, horse stables, and stone house, sheds [illegible] --- 800
i) 2 Wells with good springs --- 2,500
j) 2 Stone penns --- 2,000
k) 100 Negro houses in good order --- 10,000
l) A Large Dwelling house with Stone cellars --- 6,500
m) A Kitchen with two ovens --- 800
n) A Coatch house with Stables --- 1,200
o) A Store house --- 850
p) A Lumber house --- 500
q) A Coppers Shop --- 700
r) Stock house --- 300
s) Necessary house --- 100
t) Water Cistern --- 2,000
u) 1 Waggon, 2 Bull Carts, 1 Mule cart, of number of old Bodies and wheels, 1 pairs of new wheels unshod, 3 pieces of timber for cart wheels etc., with some small pieces of the same --- 600
v) 2 pieces of timber for wind mill points --- 100
w) Stock:

22 Draft Cattle	---	2,000
9 Cows	---	990
5 Young Steer (?)	---	250
5 heifers	---	125
5 calves	---	75
42 mules	---	520
1 horse	---	150

Land, Buildings, Stocks	---	270,850
Negroes	---	82,100
TOTAL AMOUNT	---	352,860"

[Material furnished by Erni Escalante, Virgin Islands National Park Service, Christiansted, St. Croix as photocopy of Danish census sheet for Estate Carlton; original material presumably in Copenhagen, Denmark.]

[74]Lewisohn, Divers Information. By comparison, St. Thomas and St. John had only 67 animal mills and 4 windmills at this time. [Dookhan, p. 80.]

[75]Lewisohn, St. Croix, pp. 214-216. Dookhan states (pp. 83-84) that "the destruction of [a] hurricane of 1819 had the long-term effect of convincing many islanders that the future of plantation agriculture was bleak."

[76]Lewisohn, Ibid., p. 219.

[77]Ibid., p. 220.

[78]Thurlow Weed, Letters from Europe and the West Indies, 1843 - 1862, (Albany: Weed, Parsons, and Company, 1866), p. 374 (dated 24 February 1845).

[79]Lewisohn, St. Croix, p. 220.

[80]Statistics Regarding Properties in the Island of St. Croix, 1816-1857 (n.a., 1858). Microfilm in St. Croix Public Library, Christiansted, St. Croix.

[81]The number of windmills fell from 106 in 1855 to 17 by 1878, and similarly the number of animal mills declined from 12 in 1855 to only 1 in 1878. (Dookhan, p. 223)

[82]Smith, p. 4; table "Quantity of sugar, rum, molasses exported during the years 1835 to 1897, inclusive."

[83]Lewisohn, St. Croix, p. 222.

[84]Ibid., p. 292-296.

[85]Ibid., p. 304. Dookhan (p. 223) numbers 67 steam mills in 1875.

[86]Smith, p. 6; table "Rainfall in St. Croix during the 69 years, 1852-1920."

[87]The five mills had rollers 30 inches in diameter and 60 inches in length and were powered by existing engines presumably from other St. Croix estates. Information derived from a 4-page typewritten list "Sugar Cane Crushing Plants Supplied to St. Croix," (n.a., n.d.) fur-

nished by David Hayes, St. Croix.

[88]Lewisohn, St. Croix, pp. 322-323. A map of St. Croix showing the names and location of the burned-out estates, appeared in the New York Herald, 28 November, 1878 (reproduced in Lewisohn, p. 323).

[89]Ibid., pp. 337-338.

[90]Lewisohn (Ibid.) offers some details of the factory:

"The factory had a main room 120 feet by 55 feet with high ceilings. To save $10,00 a year on a coal bill the Captain introduced the burning of green bagasse or crushed cane stalks. The huge boilers were fired from combustion chambers from which hot air flues led to the great draft-producing chimney. The enormous chimney ... has a 7 feet inside measurement tapering upward evenly for 112 feet [and] it stands on a foundation of solid masonry 11 feet deep by 24 feet square.

...These sugar works ... included a massive engine which drove the cane crusher and the mechanical belt carriers; another engine for the bagasse carriers; an evaporating plant with an engine which also ran ten pumps. Other pumps drove the water up the enormous fountain of a cooling tower needed for a new type of vacuum pan operation in the evaporating plant.

The Lower Love plant could turn out 40,000 gallons of cane-juice in 14 hours, and often did. The molasses was separated from the sugar by a battery of four centrifugal spinners; it was reboiled and used for a second-grade sugar; the molasses left from this was made into third-grade sugar."

The list of steam mills supplied to St. Croix (see note 87 above) provides the following data for the La Grange factory:

mills: 2, having horizontal rollers 26 inches in diameter by 42 inches in length; numbers 1611, 1612
engine: 2, Horizontal Corliss Frame engines with bores of 14 inches and 36-inch strokes; numbers 1924, 1925
purchaser: G. A. Hagemann

[91]Lewisohn, St. Croix, p. 302.

[92]Ibid., pp. 370-379.

[93]Knox, p. 47.

[94]Dookhan, p. 75.

[95]Knox, p. 54.

[96]Ibid. This same policy was later employed on St. John and St. Croix.

[97]Dookhan, pp. 76-77. Dookhan attributes this low figure of sugar production to "shortage of capital, of technical knowledge, and of adequate labor among the early colonists." (p. 76)

[98]Ibid., p. 73. The number of estates had risen dramatically since 1691, from 101 to 160 by 1715; after this the growth rate slowed and then reversed itself.

[99]Ibid., p. 40. See also the second chapter in Charles E. Hatch, Virgin Islands National Park - St. John Island ("The Quiet Place") with Special Reference to Annaberg Estate, Cinnamon Bay Estate, (Washington: National Park Service, 1972). Hereafter referred to as "Hatch Report."

[100]These districts were as follows: Cruz Bay, Maho Bay, Reef Bay ("Riffbay"), Coral Bay, and Eastend.

[101]Dookhan, p. 71. Nine planters were Danes, five were French Huguenots, and six were Dutch.

[102]Ibid., pp. 41-42, 75.

[103]Ibid., p. 75. Original reference: P. P. Sveistrup, Bidrag til de Tidligere Dansk-Vestindiske oers Okonomiske Historie. Med Saerligh Henblikpaa Sukkerproduktion og Sukkerhandel, (Copenhagen: Nielsen and Lydieher Bogrrykkeri, 1942), p. 23.

[104]Knox, p. 63. Original reference: Pere Labat, Voyageraux Isles de L'Amerique, (Paris: 1742), Vol. III, p. 285.

[105]Dookhan, p. 84.

[106]Knox, p. 90.

[107]Alan H. Robinson, Virgin Islands National Park: The Story Behind the Scenery, (Las Vegas, Nevada: K C Publications, 1974), p. 40.

[108]Hatch Report, p. 50.

[109]Ibid.

[110]Knox, pp. 76-77. Pages 68-77 contain a general survey of the insurrection.

[111]Dookhan, p. 79.

[112]Hatch Report, p. 55.

[113]Dookhan, p. 91.

[114]P. L. Oxholm, "A Color-Rendered Manuscript being His Survey of St. John Made in 1780," and same, "Map Over the Danish Island of St. John in America," (Copenhagen, 1800).

[115]Hatch Report, p. 56.

[116]Dookhan, p. 80.

[117]Ibid., p. 82.

[118]Hatch Report, p. 58.

[119]Randall S. Kolodis, St. John on Foot and by Car, (1974), p. 11.

[120]Ibid., p. 11.

[121]Information concerning steam machinery may be found in the drawings and accompanying historical report prepared by HAER for "Estate Reef Bay," 1977.

[122]Kolodis, p. 11.

[123]The date for this closing is variously given as 1909, 1916, or after 1925. See note 121 above for source.