system consists of twenty settling tanks, having a capacity of from twelve to fifteen hundred gallons of juice each, together with proper exhaust and live steam heaters, liming tanks, etc.

For filtering the scum from the settling tanks there are twelve presses, each having five hundred square feet of filtering surface,

Evaporation System. The evaporator is a quadruple effect, having a capacity of fifteen hundred tons of juice per twenty-four hours, reducing it seventy-five per cent in volume.

Vacuum Pans. There are three vacuum pans, each of twenty-five tons capacity, or one large pan, of fifty tons capacity, and one pan of twenty-five tons capacity, one of the pans being used for the low grade product. These pans, together with their equipment of syrup and molasses tanks, are located on the third or upper floor of the factory building.

Crystallizers. For the further treatment of the sugar, after it leaves the vacuum pans, there is a battery of twenty crystallizers, each being of sufficient capacity to hold the contents of the twenty-five ton pan. These are placed on the second floor, immediately below the vacuum pans.

Centrifugals. For drying the sugar, after delivery from the crystallizers, there are twenty centrifugals, each forty-two inches in diameter. These centrifugals, which may be either belt, water or electrically driven, as may be preferred, with their equipment of mixers, conveyors, dryers, elevators, bagging bins, etc., are placed between the ground floor and the second floor of the factory building.

Condensers. For condensing the vapors from the pans and evaporators, all of which are operated under a vacuum, and for the removal of the uncondensable gases, a central condensing plant is installed, which consists of a condenser for each of the pans and evaporators, and an auxiliary condenser from which the central condenser vacuum pump takes its suction.

Electrical Equipment. For auxiliary power throughout the factory, for running cane unloaders, revolving cane knives, driving the crystallizers, conveyors, elevators and machine shop apparatus, and for lighting the factory, an electrical plant of one hundred and fifty kilowatts is installed.

Water Supply. The necessary water supply will approximate five million gallons per twenty-four hours, and can be supplied either by gravity or by a pumping system.

Sugar Chemist's Laboratory. A complete sugar chemist's laboratory is installed, with all the necessary apparatus, for a thorough chemical control throughout the different processes of manufacture.

Machine Shop. There is a complete machine shop, equipped with lathes, drills, planers, pipe cutters, etc., and the necessary hand tools, so that ordinary repairs may be expeditiously made.

Pumps and Piping. In connection with the above machinery there is a complete equipment of pumps and pipe lines, throughout the building, for handling the juice, syrup, molasses, water service, boiler feed, etc.

Building. All of this machinery is contained in a steel frame, corrugated iron building, of specially heavy construction.

The boiling house is three stories in height, the clarification department two stories, and the milling and boiler house department one story.

In the mill room a heavy crane spans the full width of the building, and has a traverse of the extreme length of same, so that the heavy mill rollers may be readily handled for adjustment and repair.

Cost. The cost of a factory of the above dimensions would be about $650,000.

Other sugar apparatus has developed along the same lines as the extraction machinery. The Weston Centrifugal, invented by D. W. Weston in Honolulu, was first used in 1852 at Makawao. It was run by man power, and the first machine was such a curiosity that throngs of Hawaiians came to watch its operation, and it is stated that school boys would come every afternoon and run the machine till night without pay, and would dispute their turn at running it.

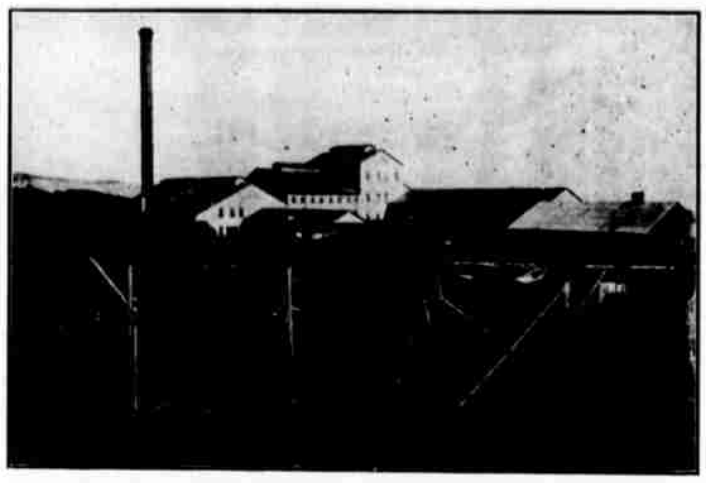
Very many improvements have been made in the centrifugal since that time, but the original idea has remained the same.

Hydraulic attachment to the mills was adopted at the time of the 5-roller mills, thereby very largely increasing the extraction. Vacuum pans were introduced in 1863 with double and triple effects in 1878, and mud presses came in generally about 1880.

Cultivation.

Improved methods of cultivation followed hand in hand with improved sugar machinery. Very early attention was given to the planting of the best seed, and there was much discussion in the early meetings of the Planters' Labor and Supply Company as to the relative values of seed from plant cane, from ratoon cane or from the tops of either plant or ratoon.

A great deal of attention was given to the best varieties of cane to plant. Climate and soil conditions varied so much in different localities, or even upon the same plantation, that a variety of cane which might do well at a low elevation would give a small yield at a higher elevation, and so while Lahaina cane was the favorite cane for many years, and still remains so, in favored localities, other varieties were tried and are yet being tried and experimented with.



Mill of the Wailuku Sugar Company at Wailuku, Maui. A Type of the Modern Sugar Mill.

Agricultural Implements.

Improved agricultural implements have been brought into use, steam plows were first introduced about 1880 or 1882, and various kinds and makes of cultivators and horse-plows came into use. The investment of the plantations in agricultural implements, most of which come from the United States, reaches a very large sum, and the up-keep and replacement of such appliances is a continual expense.

For many years the principal method of transporting sugar cane from the fields to the mill was by ox-cart or mule teams. As late as 1882 there were only eight plantations that used steam railways for transportation. **Recent information of the mileage of steam railways on plantations is not available, but in 1905 there was a total of 534 miles of permanent track owned by the plantations, 88 locomotives and 7796 cars. The investment in rails and rolling stock is thus very considerable.**

Many labor saving devices for use in cultivation and harvesting have come into general use, but nothing has yet been invented which will mechanically harvest the cane. Cane loaders are in use on some plantations, but they do not greatly reduce the cost of the operation.

Fertilizers. One of the most important factors in the matter of increase of yield due to improved cultivation, is the use of fertilizers. Fertilizers were first used on the plantations here in 1879. In the Hilo district it became apparent that the soils were not yielding as well as they had, and in that year various samples of soil at Onomea were sent to New York and analyzed, and fertilizers composed largely of sulphate of lime were recommended. From this the question of fertilizer grew. With the intensive agriculture practiced in these islands in the cultivation of sugar cane, and where rotation of crops is not followed, it became a very important problem. Owing to the wide diversity of climate and soil conditions which characterize the sugar lands of the country it became manifest that the subject of fertilization was one which must be worked out in large measure for each individual plantation. Not only must the needs of the crop be taken into consideration and weighed with relation to the quantity of plant foods stored up in the soil, but the form in which the various fertilizer ingredients should be added to render the best service, constituted a subject of equal importance.

Examining Soils.

When the Hawaiian Sugar Planters' Association established its Experiment Station in 1895 there began a systematic examination of soils both on the plantations and in the laboratories, together with the collection of data as to rainfall and temperature, which has been the basis of much of the fertilizing that has been done since that time. It is due in a very great measure to these investigations of the conditions of each plantation that the fertilizers used in one district are so different from those used in another district, and that there is a constant tendency toward high grade fertilizers which are specially prepared for the plantations where they are to be applied.

The amount of fertilizer sold in Hawaii has increased tremendously, as the following table will show. The custom house reports from the year 1885 to 1888 show the following imports:

Year.	Pounds.	Tons.	Value.
1885	2,050,689	1,025	$ 30,568.92
1886	2,747,952	1,374	36,162.80
1887	4,140,297	2,070	52,302.76
1888	5,976,271	2,988	100,879.26

The sales of fertilizers for the past four years by the two fertilizer companies operating in Honolulu have been as follows:

1904	$1,732,470.00
1905	1,974,235.00
1906	2,300,023.00
1907	2,383,195.00

Authentic figures of the amount sold to the plantations by fertilizer companies in San Francisco are not to be obtained, but closely estimated at about $75,000 per annum. In addition to this, one sugar agency imports approximately $100,000 worth of nitrate of soda per annum.

Great Irrigation Systems Developed.

Irrigation: Irrigation by Mountain Streams. When the growing of sugar cane was first started on these islands the plantings were made on the windward side of the islands to take advantage of the rainfall, and it was not until some years after the inception of the industry that it became evident that the rainfall was not regular enough, excepting in some few places, to produce the best results in cane culture, and hence the first attempts at irrigation were accomplished by damming up the streams and leading the water out by means of ditches to the head of the cultivated lands.

One of the most striking features in connection with irrigation and the conservation of mountain water is the extraordinary productiveness of some of the island water sheds. The Waihee shed on Maui, with an area of about four square miles, yields a daily minimum flow of 17,000,000 gallons, and the Olokele shed on Kauai, with an area of about eight square miles, yields a minimum flow of 40,000,000 gallons, and a mean flow of 70,000,000 gallons in 24 hours. Each of these water-sheds is particularly and favorably situated for precipitation with brush covered steep slopes and with almost daily rainfall.

Nearly all the Hawaiian streams respond very quickly to rainfall, rising and falling quite steadily, while those with a good dense brush covered water-shed hold the volume in streams almost constantly above a certain minimum.

The first ditch for the irrigation of cane was dug at Lihue, Kauai, at a cost of about $7,000 in the year 1857. There were no engineering difficulties. The results were disappointing at first, due to the ignorance in applying the water, but later experience made Lihue on eof the best paying sugar plantations in the islands.

The Hamakua Ditch. In 1876, under the initiative of H. P. Baldwin and S. T. Alexander, a company was formed to bring water from the windward slopes of Haleakala to the Haiku, Paia and Grove Ranch plantations. The ditch was 17 miles long, with a daily capacity of upwards of forty million gallons. It involved crossing precipitous gorges up to 450 feet in depth, inverted syphon riveted pipes, of a diameter of forty inches being used.

The Hawaiian Commercial Ditch. The next "big ditch" to be dug was into the same territory, but below the Hamakua ditch. It was financed by Claus Spreckels and engineered by H. Schussler; was thirty miles long, with a daily capacity of fifty million gallons, discharging at a head of 250 feet. In 1900 this ditch was intercepted near its head and supplemented by the Lowrie ditch. This ditch has a daily capacity of sixty million gallons, and delivers water onto the cane fields at an elevation of 450 feet.

The Waihee Ditch. Several years later the Hawaiian Commercial Company built a ditch from Waihee to its cane fields, reaching almost to Maalaea Bay, about ten miles, from which an average daily flow of 35,000,000 gallons is obtained.

The Makaweli Ditch. No further development in ditch building took place until the establishment of the Makaweli plantation in 1890. This ditch was over fourteen miles long, including 7,040 feet of 40-inch riveted steel syphon pipe; 1,013 feet of tunnels; 14,618 feet of flume five feet wide by forty inches deep, and delivers 35,000,000 gallons per day at an elevation of 450 feet.

Ditching After Annexation. With the exception of a short ditch from Maunawili to Waimanalo, with a daily capacity of 4,000,000, there was little ditch construction until after annexation in the summer of 1898.

The Olokele Ditch. The Hawaiian Sugar Company (Makaweli) added the Olokele ditch to its water supply in 1902-04. This ditch is thirteen miles long, through an inaccessible congeries of gorges and precipices, of which eight miles consists of tunnels, seven feet high and seven feet wide. It has a daily capacity of 60,000,000 gallons.

The Koolau Ditch. In 1903 the Hawaiian Commercial Company and the Maui Agricultural Company combined to extend their old ditch through Koolau and into the Nahiku district. This region is one of the best watersheds in the islands, but is such a tangled mass of deep gorges that it had been previously deemed unavailable for economic use. The same engineering tactics were adopted, however, that had proved so successful at Olokele. Although the ditch is only ten miles long, it crosses 38 valleys, requiring that number of tunnels through the dividing ridges, the shortest being 300 feet and the longest 2,710 feet long. The total tunnel length is seven and one-half miles. The tunnels are seven feet high and eight feet wide. The ditch has a daily capacity of 85,000,000 gallons.

Extension of Hamakua Ditch. Coincidently with the construction of the Koolau ditch the Hamakua ditch was extended to meet it and the old ditch enlarged, to a capacity of 60,000,000 gallons per day. The total length of the ditch, from Nahiku to Kihei is fifty miles.

The Honokohau Ditch. In 1903 the Pioneer Mill Co. constructed a ditch from Honokohau through Kaanapali, Maui, a distance of thirteen and a half miles, of which three and a half miles is tunneling. It has a daily capacity of 30,000,000 gallons. This plantation has also made a number of small ditches and done much tunneling for water in the adjacent valleys, with great success, one 2,600-foot tunnel, at an elevation of 2,500 feet, having produced a daily flow of a million gallons.

The Kohala Ditch. The Kohala Ditch Company, an independent water company, has completed a ditch from the Kohala mountains through the Kohala district, furnishing water to the several existing plantations, with expectation of irrigating a large additional dry area toward Mahukona. The first section of this ditch, about

Territorial Public Schoolhouse at Lawaii, Kauai.—The Kalaheo Homestead School.