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The latest dates from New York report Cuban centrifugals of 96 test at 6¼ cents, with a firm demand for raws.

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From every section of the group, we hear of abundance of rain during the past month, excepting only Kau, and hope to hear soon that rains have visited it also.

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Persons who have kept the record of rainfall in any districts of these islands are requested to furnish us with the quantity of rain during each month of 1889, and the totals of previous years where obtainable.

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The new Spreckels Refinery in Philadelphia commenced work Dec. 9, and is expected to turn out 1,000 barrels of refined sugar daily. It is probably the largest and most complete sugar refinery in America.

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A syndicate of sugar manufacturers of Paris have petitioned the government for authority to correspond directly with the French Consuls abroad to obtain information of interest to the sugar industry. The Cabinet is favorably disposed towards the request.

Thomas Ryan, the United States Minister to Mexico, in his report to the Department of State on Mexican products and exports, says the productions of sugar, corn and wheat are remarkably small. The average value of the sugar product is 5½ cents per pound and the export value is 2½ cents per pound, aggregating only $105,000. This is said to be of the most inferior grade.

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A correspondent writes from Maui that the new diffusion plant, which has been erected at Hamakuapoko, is about ready to commence operations, and is waiting only for the completion of one of Young's superheaters, which has been set up. Everything will be ready for before the close of this month and there is no reason to doubt that the new diffusion mill will be a success. A large crop is waiting only the starting up of the works.

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The beet sugar industry in Southern California is no longer problematical. Richard Gird of the Chino, has just returned from San Francisco and brings the gratifying report that the documents which will give that section sugar factories have been signed. By this contract Mr. Gird transfers to the American Refinery Company 2,000 acres of the Chino lands at a very satisfactory price, and leases 2,000 acres more for a term of years. The plant is to cost $300,000. It is to be a crude sugar factory and a refinery combined. Another crude sugar factory will be placed at Anaheim, and still a third at some other point in the county.

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Willett & Hamlen of New York have made some figures of the consumption of sugar in the United States for the year ending October 1, 1889. The year began with a stock of 108,208 tons, or about 53,000 tons less than at the beginning of the previous year. The imports and domestic receipts for the year were equal to 1,438,353 tons, the exports 8,813 tons, and the carry over stock at the close of the year 149,017 tons, showing the consumption for the year to have been 1,388,731 tons, or 35,908 less than for the previous twelve months. This is equal to a decrease of 2½ per cent and is attributed to the higher prices which prevailed for refined sugar during the greater part of the year. The consumption for 1887–88 was 4⅛ per cent in excess of 1886–87. In concluding a review for the year, the firm refers to the outlook for 1889–90 as follows: "The total supply is so heavy that high prices are out of the question."

In order to secure uniform results in the testing of sugars, the Treasury Department has directed that samples of all imported sugars shall be sent to Appraisers at Boston, New York, Philadelphia, Baltimore, New Orleans and San Francisco for re-testing, and the Appraisers are instructed to report the results of the re-tests to the Department. Assistant Secretary Tichenor has also directed that in cases of exportations of sugar or cordage, in small quantities, that the person issuing the bill of lading shall state that those articles are intended for foreign ports, and not for use en voyage. This is intended to stop the practice of securing drawbacks when these goods are exported simply for the use of vessels during the trip.

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BEET SUGAR IN CALIFORNIA.

The beet sugar factory at Watsonville, says the S. F. *Bulletin*, closed operations for the season some weeks ago. The main facts of importance are that the product paid a handsome profit to the manufacturer, and presumably a fair one to the beet growers. This successful result does not stand alone. The operations of the preceding year were also successful. The limit of the area adapted to the growth of the sugar beet in California is not known. Whenever a search for favorable soils has been made there has been no difficulty in finding large areas adapted to the culture. Without doubt the best sugar beets can be produced on an area large enough to supply many more sugar manufactories. Of course, the manufacture of beet sugar can only be conducted successfully by experts. But, probably, there would be no lack of these if a call were made for them. Seeing that capital also is abundant, what is to hinder California from producing within a few years as much sugar as that part of the country lying west of the Rocky Mountains may need.

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FORTY NEW VARIETIES OF CANE.

After the meeting of the Audubon Agricultural Association, last week, Prof. Stubbs kindly called our attention to forty varieties of new canes, grown by him at the Kenner Station this year, and that day transported to Audubon Park Station to be planted.

The ground had been very carefully prepared, and it was indeed a pretty sight to see so many distinct varieties of cane lying in bunches, side by side, all carefully labeled. Some were very large handsome canes, and all were above the average in size for this year of stunted cane. Among them were many from Hawaii, as will be seen by their names which are as follows: Akilolo, a light red cane; Honuaula, dark red;

Papaa, also dark red; Altumatia; Capengene, large dark red; Akilolo, striped; Manuleta, red, with small stripe; Ohia, light brown, two varieties; Adineka, with dark green stripe; Kaurio, striped green.

Among the other varieties were some that, for size and appearance, were very fine, but a test of a few years will be necessary to demonstrate their adaptability to our soil, climate, etc. Among them we noticed the Japan cane, a small, very hard cane, but remarkable for its sweetness and great ratooning qualities, grown in Louisiana before, but never properly tested. Our planters will all watch with interest the development and acclimating of these new varieties of cane.

Aside from the above, Prof. Stubbs has a large lot of cane in the Horticultural Hall, embracing the above and other varieties, which he will allow to go to flower, with the hope of doing as did Prof. Harrison, obtain some *seed* from them. We hope he may be that successful.—*Sugar Bowl, Nov. 23.*

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SUGARCANE FROM SEED.

Since the recent discovery at the experimenting grounds at Dodd's Reformatory, Barbados, that sugarcane could be raised from seed, the subject has received considerable attention. In the first place the truth of the discovery has been confirmed. Not only true seedlings, but seeds with the sprouting embryo have been observed. The authorities at Kew Royal Gardens are lending their assistance and encouragement to the development of the question, and it is not improbable that in a short time we shall see cane seedling nurseries established in the West India colonies for the benefit of planters. The West India committee have taken up the matter, and in the course of a correspondence with the Secretary of State, in which they state that "these experiments open up the possibility of improving the cane, and have an important bearing upon the future of the sugar colonies," they ask Lord Knutsford to draw the attention of Governors of colonies to what has been done in the matter, with the view of having similar experiments conducted in all the botanic gardens of the West Indies and "of making the seedlings available to planters." They also praise the "public spirit of the Barbados legislature for making an annual grant towards these experiments, and ask the Secretary of State to communicate especially to the Governor of Barbados, so as to insure the continuance of experiments fraught with such important issues."

High prices should also encourage sugar planters to try experiments for themselves. Up to now their relations have been a great deal too much confined to the clerk of the weather. They have large vistas opened to them by this new method of cane planting by seed; by persevering trials with varieties of cane; and chemical researches in the proportion of saccharine matter in the different varieties under the varying conditions of the seasons. All this shows that in spite of beet and its warlike propaganda by means of bounties, the world has not yet heard the last of the sugarcane.—*Exchange.*

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IRRIGATION.

Much attention is being paid now in the United States to the subject of irrigating the barren plains lying among and along the slopes of the Rocky Mountain chain, or perhaps more strictly speaking, west of the Mississippi Valley. Vast tracts, which have long been considered worthless, and termed "deserts," have been found to consist of rich and productive soil, when irrigated from the rivers that flow above them. So valuable have these waste lands become in some instances, that the United States Government has forbidden the sale of them to corporations or syndicates for speculative purposes, and proposes to reserve them for actual settlers.

The reclamation of barren tracts has attracted attention here also, since the establishment of the Spreckelsville plantation on what was once considered a worthless plain, on to which abundant supplies of water have been brought from a distance, transforming it into the largest and most productive sugar estate in the world.

Recently two civil engineers of much experience in irrigation projects were invited to visit these islands and examine into the practicability of bringing water on to the dry and barren plain west of Ewa, the property of James Campbell, Esq., covering over forty thousand acres. These gentlemen, Messrs. Schuyler and Allardt, after a thorough examination of the streams, springs and other water supplies, made a report that not less than ten or twelve thousand acres of this tract can be irrigated and made productive cane land. Their report commencing on page 537, is an exceedingly interesting one, and demonstrates some of the latent sources of agricultural wealth which exist on this island, and within sight of this city.

Another admirable article on this same subject will be found on page 569, being a paper read before the Louisiana Sugar-planters' Association. From both these reports, many items of interest may be gathered relative to the amount of water required, its cost, and the best methods to secure and handle it.

In this connection, we would urge those living in districts which receive their supplies chiefly from rain, to keep a record of the amount of rainfall from month to month, as such data will be valuable whenever efforts are made to store and utilize the mountain sources of rain water.

A VALUABLE SUGAR BOOK.

We have received from Messrs. John Wiley & Sons, 15 Astor Place, New York, copy of "A Hand-book for Sugar Manufacturers and their Chemists. containing practical instruction in Sugar-house Control, Diffusion, Methods of Analysis, Reterence Tables, etc., etc., by G. L, Spencer, of the U. S. Department of Agriculture." An examinaiion of this hand-book shows it to be most valuable as a reference for every one who is engaged in the manufacture of sugar. It is of small size, about that of a pocket diary, and in addition to the above contents, has blank forms for use in the sugar-house and also on the plantation. Its cost is said to be $2 to $2.50 per copy.

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THE NICARAGUA CANAL.

Managua, situated well in the interior of Nicaragua, on Lake Managua, is in such close telegraphic communication with San Francisco, that a dispatch from there on the 24th was received in New York the same day and published in the papers the following morning. This dispatch shows that since June 3d, when actual work commenced, the Americans have succeeded in building up the foundations of a town, which will be called America. They have landed the material for and commenced the construction of a twelve-mile aqueduct, have laid a mile or more of broad-gauge railroad; have placed thirty-five miles of telegraph line in operation; have cleared the San Juan, Juanillio, Descada and Silico rivers; have built twenty or more permanent camps; have cleared the first part of the route of the canal, organized a perfect supply and transportation service, a hospital service and an ambulance corps; have perfected sanitary arrangements, and have done everything possible to win the good will of Nicaragua and show the world what American push and intelligence can do under the most difficult circumstances. The rapids in the San Juan river will disappear, as the water of lake and river is raised by the Ochoa and other dams. The steamer having on board the American canal party crossed the lake and the members had seen the canal location, which (after passing through the lake) will cut through to the Pacific side of the coast, an air line over only eleven miles of land, river, swamp and basin seperated the American engineer from the Pacific Ocean. The necessary funds have been raised, the skill, talent and muscle are being applied to the work, and it is now but a question of a very few years when the canal will be finished and the steamers leaving

Pacific ports can discharge at New York without breaking bulk, and the "coasting" voyage between Atlantic and Pacific ports shortened one-half.

This great work is destined, when completed, to add largely to the importance of our archipelago, which is the only central station in the North Pacific, midway between the American and Asiatic continents. It is none too soon for our law makers to provide the ways and means for deepening the entrance to our harbor to thirty feet, and constructing wharves and warehouses on its western and northern sides even if it has to be done by public loan. Before this work can possibly be done, the large 6,000 ton steamers filled with freight and passengers, will be knocking at our door for admission, and admission they must have or they will abandon this for some other port.

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PROSPECTIVE SUGAR CROP ESTIMATES.

Estimates have been published in various American and European papers, of the probable cane sugar crops for 1890. These are chiefly based on reports from cane growing countries. Sugarcane takes from twelve to twenty months to mature, and during this long period is liable to various vicissitudes, affecting more or less the yield. Six or seven countries now produce the bulk of the cane sugar crops, viz: Cuba 600,000, Java 300,000, Manila 180,000, Brazils 170,000, Louisiana, Mauritius and Hawaii, each 125,000 tons, while some twelve or more countries report crops varying from 100,000 to 30,000 tons each. Altogether the cane sugar crop has averaged of late years about 2,300,000 tons, and this is taken as an average for future estimates.

The crop for the year 1889, now closing, has been put at 2,280,000 tons, which is probably about correct, while the forecast made for 1890 has been put at the usual figures, or 2,300,000 tons. The yield in the older sugar countries, however, shows a gradual falling off from year to year, from various causes, particularly in Java and Mauritius, which may be attributed in part to the land having been overworked, and in part to the new disease called *Sereh*, a species of withering blight, which, so far as is now known, has never been described as affecting cane elsewhere, in any part of the world. Presumably it has originated in Java, and in consequence of the cane lands having been for many years, if not a century, cropped without having been properly regenerated with fertilizers, which are absolutely necessary for preserving its strength, and for imparting vigor to the exhausting cane crops. If the reports which reach us from time to time are correct, it is a very dangerous enemy, and to arrest its spread, to exterminate it, and prevent all export and import of diseased canes, no expense should be spared. The result in Java and Mauritius will be to steadily decrease the annual outcome until some effectual remedy is found, or until the cane lands have been restored to their normal healthy condition.

In the annual cane estimates, due allowance has not been made for the loss caused by this disease, which will effect an annual falling off in the sugar product of those countries of probably not less than ten per cent, without a corresponding increase in other countries. The crops in Brazil and Cuba are liable to considerable fluctuation from year to year, from scarcity of labor, weather, fire and other mishaps, more marked than in other sugarcane countries. Consequently there is very small chance of any increase in the world's cane product for years to come, with much probability of a decline. Whatever decline there may be in the yearly product of cane, must be made good by an increase in that of beet sugar. And it is to this branch of the sugar industry that the world must look to meet its steadily increasing use for food and manufacturing purposes. The lower classes of Europe are but just beginning to use sugar as a staple article of their food, having acquired a taste and fondness for it while engaged in its production. This demand for beet sugar will grow in Europe from year to year faster than the annual increase in its production, and most of the beet sugar produced there will probably be consumed there, so long as the price is as low as the average in years past, and no great export of beet sugar can be made from Europe without causing an advance in its price.

America, then, must look to her own wild, and as yet unutilized prairies for the supplies of sugar which will be required to meet the demands of her rapidly-increasing population, expanding now at the rate of from one to two millions each year. Latest estimates of the annual sugar consumption in the United States per capita, place it at over fifty (50) pounds. This at the lowest figure of increase named would require fifty million pounds more each year to supply her own wants. The cultivation of beets is the only solution of this sugar question and unless its growth and manufacture soon become a leading industry, the price will remain at a figure which will make it a luxury, as it has long been in Europe, and retard its use as daily food of the masses.

Under these circumstances, the prospect of a market for our island sugars promises to be as good as it now is, probably for twenty years to come, even if the total of our annual crop should reach 150,000 tons, as those best informed think it will in a few years. Beet sugar is improved by a mixture with cane sugar in refining, and for this reason, there will always be a demand for the latter.

CORRESPONDENCE AND SELECTIONS.

REPORT ON WATER SUPPLY FOR IRRIGATION ON THE ISLAND OF OAHU, HAWAIIAN ISLANDS

B. F. Dillingham, Esq.—*Dear Sir:* The purpose of the invitation extended to us by you to visit the Hawaiian Islands was, as we understand it, to obtain the opinions of engineers qualified by practical experience in hydraulic works, as to the water supply available for irrigation in certain portions of the Island of Oahu, and the practicability of establishing extensive plantations of sugarcane on the Honouliuli ranchos and the Kahuku lands, to be supplied with water for irrigation by certain general plans suggested by you. We have examined the lands in question, have measured numerous springs and mountain streams, have examined various sites for storage reservoirs and have made a somewhat detailed study of the practice of irrigation of sugarcane on this and adjoining islands of the group, and report our conclusions as follows:

THE NECESSITY FOR IRRIGATION.

Although sugarcane is successfully grown in some localities on the windward side of the islands of Hawaii and Maui without artificial irrigation, it appears to be confined to localities where the annual rainfall is somewhat evenly distributed through the year, and in volume equal to or exceeding the quantity which experience has shown to be necessary to apply to dry lands to mature a crop. These conditions do not exist on the Island of Oahu except on mountain slopes too steep for cultivation, or in some localities on the windward side, where some irrigation would nevertheless be advantageous.

It therefore goes without saying that irrigation is so essential to success in agriculture that no cane can here be grown without it, notwithstanding the fact that the minimum rainfall generally exceeds twenty-four inches (which in California is ample for nearly every crop grown there without irrigation) along the coast, and from forty to ninety inches on the mountain slopes.

THE DUTY OF WATER.

The necessity for irrigation being thus recognized and established, the quantity of water required in irrigating various crops becomes the next consideration, or, in other words, the duty that may be expected from a given volume of continuous flow. Our investigations on this subject have been as thorough and exhaustive as our time would permit. They have been conducted in detail, not only on this island but elsewhere in the group, although confined solely to the culture of sugarcane, which we have understood is the product to which it is desired to devote as large an area of the lands in question as may be possible.

Rice and sugarcane require more water than any other irrigated crop, the world over, the former needing considerably more than the latter. In Spain and in India a cubic foot of water per second in continuous flow will irrigate from twenty-five to thirty-five acres of rice, and from forty-five to sixty-five acres of sugarcane. These are about the limits given by all authorities on the subject, not only in the countries named, but in Algeria, Egypt, Italy, Japan and other portions of the globe where these products are grown. We have found these figures to be substantially corroborated by the experience in these islands in the irrigation of sugarcane. It seems to be the general practice here to irrigate "plant" cane every three to four days for the first month after planting, or until it has made a strong growth of root and stalk. After that a watering is given once every seven days for a time, diminishing to one watering every ten days, which is continued for about fifteen months from the time of planting, or until the maturity of the cane. It is customary to cease irrigation for from one to three months before cutting. If, as in some districts, the cane did not mature short of eighteen to twenty months from time of planting, the period of irrigation would be from fifteen to eighteen months. In making our estimates we have assumed that fifteen months of irrigation would be the average required for sugarcane on this island. Three waterings a month is the least that is considered safe to apply to keep the cane growing without check. In localities corresponding in position and climate with Honouliuli it is customary to maintain this periodical irrigation regardless of the rainfall. The rain may at times exceed the quantity applied artificially, but irrigation is performed as usual notwithstanding, in order that there shall be no break in the continuity of the waterings. It seems to be generally understood by all planters that the depth of each watering shall be at least an average of three to four inches over the whole surface. Where the intervals between waterings are ten days and the depth applied four inches, one cubic foot of water per second will perform a duty of 59.5 acres. With intervals of seven days and the same depth applied, one cubic foot per second would irrigate but 41.6 acres, or 55.5 acres if the depth applied is but three inches.

On the plantation of the Hawaiian Commercial Co. at Spreckelsville, Maui, we were enabled to obtain more exact data than elsewhere, owing to the admirable system of records kept by direction of Hugh Morrison, Esq., general manager, who kindly furnished us with all information asked. The plantation is irrigated from the Haiku ditch, gathering its supply from some twenty small streams to the eastward of the plantation, and by the Waihee ditch, deriving its waters from the Waihee creek, some miles to the west. Each ditch delivers to the plantation a maximum supply of about 65 cubic feet per second, but this maximum is not often reached, and the ditches appear to be subject to great fluctuation in supply. Several small storage reservoirs along the route serve to equalize the fluctuating discharge to some extent. Measuring weirs are placed on each in such position that the quantity of water actually delivered to the fields is recorded with great exactness by automatic registering apparatus. The volume of water put upon every field is thus known, and the date and quantity of each watering. The records further show in every detail all the results obtained from each field, including the average yield of each in sugar per acre, as well as per unit of water applied. The record for the Calendar year 1888 shows that there was delivered to the plantation the following quantity of water:

From the Haiku ditch, cubic feet	1,175,000,000
" Waihee " "	919,000,000
A total of cubic feet	2,094,000,000
Or gallons	15,700,000,000

(The rainfall during this period was 19.08 inches.)

With this water there were irrigated 2,000 acres of "plant cane," and 600 acres of "ratoons" (volunteer second crop). In addition, 400 acres of seed cane were irrigated once a month; consuming a quantity, roughly estimated, of 70,000,000 cubic feet. The remaining 2,024,000,000 would be equivalent to an average flow through the year of 64.18 cubic feet per second, which divided into 2,600 acres would appear to give an average duty of but 40.5 acres per cubic foot per second, and to indicate that the mean depth applied was nearly eighteen feet in the aggregate. An explanation of this seemingly low duty may be found in the fact that the ditches supply water for all other uses on the plantation as well as irrigation. The amount consumed by the sugar mills, steam boilers, locomotive steam plows, as well as some 1,500 employees, some of whom have little gardens to be irrigated, if it could be known, would be very considerable in volume. In addition to this the loss by evaporation and percolation in the ditches and reservoirs below the measuring weirs is doubtless considerable, all of which if deducted from the total volume delivered, whould probably raise the duty of the remainder to more than fifty acres per cubic foot per second.

Mr. Morrison states, as an epitome of his experience, that "11,000 cubic feet per acre applied every seven days, will produce the very best results in growing sugarcane." This measure would give a duty of sixty-five acres per cubic foot per second.

Mr. Morrison further adds that it is almost impossible to put on too much water (of course within reasonable limits) and that the more water is applied without going to extremes, the greater the yield. He has obtained a yield as high as ten tons of sugar per acre, in localities sheltered from the wind. The average yield for 1888 on 2,000 acres of plant cane was $5\frac{3}{4}$ tons of sugar per acre. The ratoon crop averaged $3\frac{1}{3}$ tons per acre.

With these figures one may form deductions as to the productive value of water. The total sugar crop was 13,500 tons. The total "water crop," if we may be allowed the expression, was an average flow of 64.18 cubic feet per second. The ratio of water to sugar was about 210 tons of sugar to each cubic foot per second of water continuous flow. In other words, if we assume sugar to be worth $40 per ton after deducting cost of production, interest on plant, tools and lands, the value of the water may be taken in the ratio of the results accomplished by it, viz: $8,400 per annum for each cubic foot per second of continuous flow. This would represent interest at ten per cent on $84,000. Water can be pumped 100 feet high at less than one-fifth of the annual producing power quoted above.

On the Wailuku plantation, Island of Maui, where the water supply is very abundant and in excess of the needs of the plantation, the consumption is equal to a duty of about fifty acres per cubic foot per second on plant cane, and sixty acres on ratoons.

On the Hamakuapoko plantation, Maui, similar results were inferred from the statements received, although no definite data was obtainable.

On the Waialua plantation, Oahu, the results obtained are greater than those observed elsewhere. We were shown a pipe line, nine inches diameter, two miles long, leading from the Kaukonahua gulch, (from which all the water for irrigation is derived) with a fall of sixteen feet per mile, the flow from which irrigates 100 acres of sugar cane, as we were informed. The discharge of such a pipe would be a 1.11 cubic feet per second, and the resultant duty ninety acres per cubic foot per second. Another nine inch pipe line discharged 1.17 cubic feet per second, and also irrigated 100 acres. The duty of the water so delivered was an average of eighty-five acres per cubic foot per second. A ditch carrying $3\frac{1}{3}$ cubic feet per second was said to water about 200 acres, an average duty of sixty acres per cubic foot per second. The location of this plantation, on the windward side of the island, where the rainfall is much greater than on the lee side, may account for the higher duty accomplished by the water in use, although no data was obtainable as to the extent or distribution of the rainfall on that side.

On the Kekaha plantation, Kauai, water is obtained by pumping to a height of eighteen to thirty-six feet, an average of about twenty-seven feet. The delivery of the water is contracted for at the rate of $35 per acre per annum. The contractor is required to deliver sufficient water to irrigate 700 acres every ten days to an average depth of four inches at each watering. The duty thus performed, presuming the quantity contracted for is fully delivered, would be 59½ acres per cubic foot per second. The pumping is done during ten hours each day. The three pumps require to have a capacity of 7,000,000 gallons per day each. Coal costs $14 per ton at the pumps.

A very unusual yield is reported from this plantation. Ratoon crops for seven consecutive years are said to have produced an average of five tons of sugar per acre each year. Our authority for these results is Mr. Glade, of the firm of Hackfeld & Co.

The conclusions that may be drawn from all the evidence we have obtained on the subject are:

1. That while the duty of water is variable with all the varying conditions of soil, climate, rainfall, wind, exposed or sheltered position, and in some degree with the length of time the land has been irrigated, such variation is between the limits of forty acres at the minimum and ninety acres as the maximum duty of one cubic foot per second.

2. That economy in the application of water below a certain limit, which for the southerly slopes of this island, seems to be about an average of one foot in depth per month, can only be exercised at the expense of the yield of sugar.

3. That a greater duty than sixty acres per cubic foot per second cannot be counted on with safety, or in other words, that 328,500 gallons per acre are needed monthly, or to mature a crop say fifteen times that amount, or 4,927,500 gallons are required. In estimating on the cost of pumping water for irrigation these are convenient figures to remember.

THE WATER SUPPLY.

Our attention was first directed to the water supply that might be made available for irrigating Honouliuli rancho. This great body of land is bounded on the west for some twelve miles by the summit crests of the Waianae Mountains, a range isolated from the main central range of the island, or the Koolaupoko Mountains. From the foothill slopes of the Waianae range a broad plain sweeps south and east to the eastern boundary of the rancho, to Pearl Harbor and to the ocean. This plain at its northerly limit has an elevation of 900 to 1,200 feet. That portion above an elevation of 150 feet is some nine miles long, one to two miles wide, and has an area of about 12,000 acres. Below an elevation of twenty feet is a broad extent of coral lands extending from Pearl Harbor along the ocean to Waimanalo, containing some 11,000 acres. The rancho, exclusive of Puuloa, has a frontage of nearly five miles on Pearl Harbor and eleven miles on the southerly sea-coast of the island.

The area of the arable and irrigable lands is about 17,000 acres (not including coral lands) divided as follows :

From Surveys of C. H. Kluegel, *C. E.*	Below 50 feet elevation	1,637 acres
	Between 50 and 100 feet	2,276 "
	" 100 " 150 "	1,177 "
	At Waimanalo (estimated)	600 "
	Plains above 150 feet elevation (from map)	12,000 "
	Total	17,690 acres

The arable land below 150 feet elevation extends from the right bank of Waikele gulch in a south-westerly direction about five miles and is from one to three miles wide. The surface of this land as well as that of the upper plain to the north is generally smooth, only broken by occasional dry gulches from the mountains, which in winter bring down occasional torrents of water heavily laden with silt and vegetable mold which is deposited upon the lower levels of the plain.

The soil seems of exceptional quality, and by comparison with other plantations appears to be well adapted to the culture of cane. It has been so pronounced by experts more capable of judging than ourselves. It is probably a conservative estimate to place the area of sugar land at 14,000 acres—5,000 below 150 feet elevation, and 9,000 from 150 to 900 feet above sea level. This area would require for its irrigation a quantity of water equal to 233 cubic feet per second. To what extent this water may be obtainable, and from what sources will be considered.

There are no natural living streams flowing through or across this tract from the Waianae Mountains, and although we made no special examinations to determine what might be done in the storage of storm waters, their steep slopes seem rather unfavorable for the existence of any extensive natural sites for storage reservoirs, although something may be done by the tank system on the plains themselves. A careful topographical survey of the property would give this information. The other sources of supply available are :

(1.) Storage reservoirs on the Waikakalaua and Kaukonahua gulches, both of which have large watersheds and living streams, and have favorable sites and good material available for storage reservoir dams. The same may be said in a lesser degree of the Kipapa gulch, while the Waiawa gulch, farther to the eastward, affords a superior reservoir site near its mouth.

The first three named could be conveyed to the higher levels of the plain; the last could only contribute to the lands lying below eighty feet elevation.

(2.) Natural springs of large volume that burst out around the margin of Pearl Harbor.

(3.) Artesian wells.

The first named supply could be conducted to the lands by gravity; the second and third would involve the lifting of the water to the required height by pumping.

Our attention was first called to the springs that burst out from the foot of the low bluffs and along the margin of the semi-swamp land of Pearl Harbor, and we cannot here refrain from expressing our surprise and astonishment at their phenominal volume and extent. They furnish a supply for irrigating some 2,000 acres of rice fields, and a large area cultivated to bananas and taro, and in addition such large quantities go to waste, or at most are only used to furuish water power to various rice mills, that strong streams navigable for small boats pour continuously into the bay.

It is owing to this great supply of fresh water that Pearl Harbor doubtless owes its existence, and the coral insect has been kept from closing its entrance.

The largest and strongest streams come from the bluff at a height of twenty to twenty-five feet above tide level, and from this height all the way down to sea level the slopes for miles are like a great sponge full of water, oozing out in a myriad of little streams. Even in the bay beyond the shore springs break out so strong that it is said cattle and horses have been seen to wade out to them, plunge their noses under the salt water and drink from the fresh fountains bubbling up from beneath.

Our measurements were confined to the streams which now flow to waste unused for irrigation. The first was at Kalanao, near the mouth of Waimalu gulch, at Ah In's rice mill, where a portion of the stream is used to turn an overshot wheel. The total flow in the boat channel below the mill was found to be 27.8 cubic feet per second. The aggregate of the flow at Aki's rice mill was found to be 10⅓ cubic feet per second. The Puikani springs, about one-fourth of a mile west of Aki's rice mill have a flow of 13.4 cubic feet per second.

In the vicinity of the present terminal station of the Oahu railroad are springs having an aggregate flow of 9¼ cubic feet per second.

The unused water from springs near the mouth of the Waiawa gulch is about five cubic feet per second in volume. Large springs lying near and southwest of Waiawa church are held up to the highest limit of their flow to obtain power to turn a rice mill. The free discharge from these aggregate about eight cubic feet per second.

We recapitulate the measured flow of unused water as follows:

	Flow in cubic ft. per second.
Ah In's rice mill springs..	27.80
Aki's " "	10.33
Puikani "	13.40
Mausoleum "	9.25
Waiawa Gulch "	5.00
Waiawa rice mill "	7.83
Waikele Creek "	42.50
Total	116.11

These springs all lie within a range of three miles, and as before explained, the volume here given represents only the larger streams that were gathered in such channels as admitted of measurement, and such as were not already appropriated and used for irrigation of the extensive rice fields that fringe the bay below them. It represents, too, the natural flow forced out against all impediments, and that after eighteen months of exceptional drought.

We do not hesitate to say that a systematic development of these springs would result in a large increase of the flow. Small drains in all directions through the extended areas of oozing ground, now so wet as to make unsafe footing, would so facilitate the drainage as to cut off the water that finds its way to the sea without entering the channels where the flow was measured. In southern California, where similar springs or *cienegas* are of frequent occurrence, development by drain ditches, tiles and borings has not uncommonly resulted in double and sometimes quadruple the natural flow. A definite plan for such work can only be laid out after special survey and study of each locality is made. The present measured flow as given above, is sufficient to irrigate 7,000 acres of sugar-cane, and we have no doubt that the supply can be increased sufficiently to provide for 10,000 to 12,000 acres if necessary. It would not be a difficult matter to collect all the water into one central pumping station if it was considered necessary to do so. It would probably be preferable to establish two or more pumping plants and deliver the water from each to the plantation nearest the supply.

THE ARTESIAN WELL SUPPLY.

The discovery of the possibility of obtaining a supply of flowing water by deep artesian borings around the margin of this island has been of incalculable value to all property interests, and has compensated in a measure for the loss occasioned by the perpetual robbery of the waters that fall so copiously upon the mountains, by the porous and thirsty earth, and for the waters lost during torrential storms by rapid drainage into the sea. On no other island of the group has nature provided for such compensation, and even here the geological formation is so different from that of any other region the world over where artesian water is obtained by boring, that no scientific man would have risked his reputation by predicting the possibility of securing flowing wells by boring in the volcanic and coral formations of this country before success had demonstrated the fact.

Mr. James Campbell, the present owner of Honouliuli and Kahuku, is credited with the honor of having been bold enough to try the experiment which resulted in the first flowing well in the kingdom. This well was bored ten years ago on the lower slopes of Honouliuli rancho, and a good flow obtained at a depth of 273 feet. It has been followed by so many successful attempts in the same direction that the flowing wells on the island now number over 100, some of which equal if they do not exceed the flow of the largest and famous wells in California. One of a group of four wells bored by Judge McCully, on King and Beretania streets, Honolulu, was carefully measured a few days since by Messrs. Allardt and Kluegel, and the flow was ascertained to be 3.98 cubic feet per second, or 2,580,000 gallons in twenty-four hours. The combined flow of the four wells was ascertained to be 10.68 cubic feet per second, and two of the smallest of them, flowing 4.1 cubic feet per second, are now made to irrigate 100 acres of rice.

A marked peculiarity of this artesian belt is that it is confined to a marginal rim around the island, from sea level back to an elevation twenty-one to forty-two feet above. In and around the city of Honolulu, or the Kona district, water will flow at the maximum height of forty-two feet. In this district also the largest and strongest wells are obtained. In the Ewa district, which includes all the margins of Pearl Harbor and Honouliuli, the limit of rise is thirty-two feet; in the Waialua district it is twenty-one feet; and in the Koolau district, on the north side of the island, embracing the Kahuku rancho, the limit is twenty-six feet. This data is obtained from the last edition of *Thrum's Almanac*, in which is given a list of all the wells and their depths. From this list it appears that the deepest flowing well is that of Hon. C. R. Bishop, in this city, 1,000 feet in depth; the one of least depth is at Waialua, on Dickson & Paty's ranch, 200 feet in depth; 500 feet is thought to be about the average depth.

A record of one of Judge McCully's wells shows the following strata passed through:

Surface soil; coral; gravel, with water that rose a little way in the pipe; volcanic ashes and pumice; rock; water-worn boulders; ashes; volcanic rock; clay; water-bearing gravel.

Experience thus far indicates that flowing water is almost certain to be obtained anywhere around the margin of the island where the surface is lower than the limits heretofore mentioned. The foot of Diamond Head seems to be an exception to this rule, Mr. Campbell's well, 1,500 feet in depth, having failed to yield a flow.

Up to date it may be said that the artesian supply is practically unlimited, as the addition of new wells does not diminish the flow of others in their vicinity. There seems to be a more or less direct connection between the wells and the streams from the mountains, and we have been told of at least one well that flows muddy water some hours after a heavy storm. The springs that appear at and above sea level all around the island, and the artesian wells undoubtedly have one and the same source of supply, and are fed from the same interior basin that overflows at sea level. This supply is maintained by direct absorption of the rainfall by the porous lava rock, and by infiltration from the mountain streams. The fact that water will rise in the well pipes a few feet higher than the level at which the springs appear, indicates that the open well pipe affords a freer outlet than is afforded by the seams and crevices through which the water of the springs is forced, permitting the water to rise to nearly its full static head. The probabilities are that the island is surrounded by deep, thick strata of impervious clay or sedimentary formation, built up by slow deposit from the wash of ages by the streams of the island, that these strata lap on to the land to the height the water rises in the wells, brought up by the gradual rise of the island above sea level, and that these strata prevent the escape of the waters into the sea beneath them.

However, it is not our purpose to burden this report with scientific theories of little practical value. If it *is* true that the wells and the springs *are* supplied from the same source we do not think this source is sufficiently limited to cause any apprehension that the extended boring of artesian wells on Honouliuli plains would diminish the flow of the springs.

It would be equally fruitless to attempt to estimate the amount of water obtainable by boring wells. So far as any one knows it is unlimited. If you obtain control of the unused springs around Pearl Harbor, they alone are more than sufficient to irrigate all lands below a height to which it will pay to pump water, and the probabilities are that wells would only be bored in case you failed to obtain sufficient water from other sources, or in localities so remote from the springs that it would be cheaper to bore for water than to carry it long distances through pipes or ditches. Both springs and wells seem to be at your command, and so far as we are able to judge, either may be made to suffice for your purposes.

PUMPING WORKS AND COST OF PUMPING.

To utilize either the springs or artisian wells for irrigation will involve the erection of pumping works.

As heretofore stated, exclusive of the 600 acres estimated as available for growing sugarcane at the Waimanalo end of the coral lands, there are 5,500 acres of good tillable land below an elevation of 150 feet, of which seventy-nine per cent or 4,300 acres are below 100 feet altitude.

The 600 acres at Waimanalo should be supplied by artesian wells—on account of their remoteness from the other sources of supply. The greater portion of the tract is said to be below fifty feet altitude, consequently the cost of pumping would be comparatively moderate.

The remaining 5,500 acres will require about ninety-two cubic feet of water per second, to irrigate it fully. Nearly one-half this quantity, as we have stated heretofore, is running to waste on Waikele creek, and if the right to use it is secured, a plantation of 2,700 to 3,000 acres could be immediately started.

If we knew definitely whether the irrigable lands were to be divided into one or half a dozen plantations we could formulate more definite plans of the pumping plant, water conduits, etc. In default of this information we can only make estimates from hypothetical cases.

Assuming that all the springs were under one control and that the water were to be supplied to the lands under one management, the design of the works would be simpler than if the land were cut up into several plantations each pumping water by separate systems.

It is, perhaps, unnecessary to remark that water may be pumped in large quantities at less average cost per 1,000 gallons than in small quantities, and that the most economical engines are those which extract the greatest amount of power from a given quantity of coal, or that do the most work per unit of coal. Engines of the compound condensing type are used for this class of work, because of their high duty. They require to be run continuously, however, night and day, and for this reason provision must be made for storing the water pumped at night for use the following day, as it is not considered practicable or desirable to irrigate sugarcane at night, on account of the difficulty of doing the work properly without injury to the cane. The best engines should give a duty of 100,000,000 foot pounds per 100 pounds of coal. Direct acting engines do not often exceed 60,000,000 foot pounds per 100 pounds of coal, while centrifugal pumps forcing water about twenty to twenty-five feet do not give a greater duty than 20,000,000 to 25,000,000 foot pounds. The expense of operation for a permanent plant becomes a serious, and indeed, the main consideration where such a wide range of duty is obtainable from different classes of pumps.

We submit the following as a reasonable estimate of the cost of a pumping plant capable of delivering 30,000,000 gallons per day to a height of 100 feet, a quantity sufficient to amply irrigate 2,800 acres of sugarcane :

ESTIMATE.

Five compound condensing engines each having a capacity of 6,000,000 gallons daily. Steam cyls. 20 inch and 36x48 inch running 33 rev. per minute, water cyls. 14½x48 inch stroke @ $32,500	$162,500
Seven 180-H.P. Heine Safety boilers @ $4,000	28,000
Foundation for engines, 35,000 cub. feet concrete @ 60c	21,000
Brick work	6,500
Erecting engines and boilers	16,000
Excavations, pump, well, etc	10,000
Piping and feed pumps	12,000
Engine house	25,000
Freight to Honolulu	5,000
Total	$286,000

To this must be added the pipe needed for delivery to the lands at the height required. The diameter of this pipe should be thirty-six inches, giving a maximum velocity of 6.6 feet per second. If the plant were located on Waikele creek, near the public road, or but a little way below, the length of pipe necessary would be very short to reach the lands, say about 3,000 feet, and its total cost laid would be about $14.000.

The engines here estimated on are the best type of Corliss-Reynolds horizontal pumping engines, as manufactured by the Risdon Iron Works of San Francisco, by whose agent in this city, Mr. Jno. Dyer, the above figures have been verified.

The cost of pumping per day will be about as follows :

	Daily Expenses.
One chief engineer at $175 per month	$ 5 75
Two assistant engineers at $100 each per month	6 65
Three coal passers at $40 each per month	4 00
Five oilers at $40 each per month	6 65
Fifteen firemen, in three shifts, at $40 each per month	20 00
Oil and waste, say	39 45
Coal, on basis of 2½ lbs. consumption per H.P. per hour:	
700 H.P.×2½=1758 lbs. per hour=18¾ tons per 24 hours, at $10 per ton	187 50
Total	$270 00

This gives an average cost of nine-tenths of one cent per 1,000 gallons. The estimate is sufficiently large, and with good Sydney splint coal should not be exceeded. Applied to the quantity required for irrigation the cost foots up about three dollars per acre per month, or one dollar for each watering per acre, or about thirty-six dollars per acre per annum, or forty-five dollars per acre per crop. For a lift of 200 feet the cost of engines would be about fifty per cent greater than for a lift of 100 feet, and the expense of operation would be about double the above figures, or say ninety dollars per crop, or seventy-two dollars per annum.

In California this expense for water would be considered prohibitory, and unjustifiable by the returns from any crop that can there be produced; but here a greater cash yield may be had from a crop of sugar grown from raw land in eighteen months than is obtainable from the best of their orange groves after twelve to fifteen years of cultivation, and so what would otherwise appear as an excessive tax becomes within reasonable bounds.

We have the permission of Mr. Hugh Morrison, general manager of the Spreckelsville plantation, to quote him as giving his deliberate opinion that on good sugar land—by which is meant land that will yield good average crops of sugar—one can afford to pay as much as $100 per acre per annum for water sufficient to irrigate it abundantly.

With sugar at six cents per pound and an average yield of but four tons per acre per crop, the gross yield would be $480 per acre, and the net returns about as follows:

Cost of irrigating, stripping, weeding, cutting, transporting, grinding and manufacturing, say $50 per ton [Mr. Morrison states that the average cost of his entire crop of 1888, landed in San Francisco, was but $44 per ton] four tons at $50	$200 00
Water, lifted 100 feet high	45 00
Interest on pumping plant for 2,800 acres, costing $300,000, at 10 per cent, for 15 months=$37,500=$13.40 per acre	13 40
Total	$258 40

This leaves a net return per acre of $221.60, or, on a plantation of 2,800 acres, a net yield of over $600,000 per annum.

It would be advisable to develop all the land that is irrigable below an elevation of 100 feet before planning pumping works for a higher lift. As we have seen, the area below that level is sufficient for the establishment of a greater plantation than is now in existence on any of the islands, with water in abundance for it.

STORAGE RESERVOIRS.

There is abundant evidence to show that during heavy storms all of the main streams from the mountains carry large volumes of water to the sea, notwithstanding the fact that a very large percentage of the rainfall is absorbed by infiltration into the porous earth. This infiltration would be much greater than it is if all the rainfall came in gentle showers, evenly distributed through the year; but whenever storms occur in which the precipitation exceeds one or two inches in twenty-four hours, absorption cannot take up the water as fast as it comes, and the excess finds its way rapidly into the streams and flows away. Every stream shows high-water marks that indicate the frequency of such storms, which are said to occur with more regularity in the winter months, but may be expected throughout the year at any time. These high-water marks also indicate that very small watersheds may yield a large quantity of water, and though there is no guide as to the duration of the freshets or the intervals between them, they show that the rainfall on the mountains must at times be very great. The only rainfall records available as an indication of what a mountain precipitation may be, are those kept for seventeen years, from 1867 to 1884, by J. H. Wood, in Nuuanu Valley, 2¾ miles back from the sea-shore, and at an elevation of 554 feet above tide, and by Mr. J. K. Wilder, in the immediate neighborhood of the former, for six years, from 1879 to 1884. Mr. Wood's record is as follows:

Year.	Inches.	Year.	Inches.	Year.	Inches.	Year	Inches.
1867	75.21	1872	65.46	1876	88.57	1880	95.28
1868	77.10	1873	67.03	1877	54.12	1881	78.86
1869	53.87	1874	80.16	1878	49-12	1882	54.69
1870	80.29	1875	55.89	1879	95.94	1883	50.62
1871	67.14						

The mean rainfall for this period was 62.6 inches. For six years, from 1879 to 1884, the mean rainfall was 69.48 inches, distributed as follows:

Jan. 9.69	Mar. 8.12	May 3.28	July 5.55	Sept. 3.88	Nov. 5.06
Feb. 3.82	April 6.20	June 6.52	Aug. 6.38	Oct. 4.62	Dec. 6.78

The greatest rainfall in the different months during this period was as follows:

Jan. 27.14	Mar. 14.01	May 8.44	July 7.12	Sept. 5.40	Nov. 7.53
Feb. 6.44	April 7.69	June 9.73	Aug. 7.64	Oct. 10.12	Dec. 9.02

The records of Mr. Wilder agree practically with those of Mr. Wood.

The well-known fact that the rainfall increases in more or less direct ratio with the elevation and the further fact that the records here quoted, show an increase of 100 to 150 per cent greater than that at or near sea level in Honolulu, would justify the belief that at elevations from 1,500 to 2,000 feet the mean precipitation is at least double that recorded at 554 feet elevation, and probably much more. Our own observation since coming to the islands is that rain is falling on the mountains more than half the time when there is no rain on the coast. In the absence of more exact data we have assumed, as a conservative estimate, that not less than an average of 80 inches of rain falls annually on the watersheds of the southerly side of the Koolaupoko mountains, of which forty-five per cent or thirty-six inches runs off to the sea, available for any storage reservoirs that may be built.

WAIAWA GULCH RESERVOIR.

The first reservoir site surveyed was on Waiawa gulch, one-fourth mile above the Ewa road crossing, where a dam, having an extreme height of ninety-three feet, and a length on top of 807 feet, will store 3,631,312,500 gallons of water, making a reservoir covering 276 acres, having an extreme length of 2¼ miles. The best material available is an excellent quality of red earth, or clay, which is sufficiently abundant in the immediate vicinity. An earthen dam, with a width of twenty feet on top, upper slope 2½ to one, lower slope two to one, would contain 258,700 cubic yards, and should be built, with all accessories, for $175,000 to $200,000.

Its area and capacity at different levels is given in the following table:

Elev. above sea level, feet.	Area in acres.	Total contents. Gallons.
30	22	
40	78	163,500,000
50	119	485,062,500
60	147	919,312,500
70	170	1,437,843,750
80	198	2,039,343,750
90	250	2,177,718,750
100	276	3,631,312,500

Sixty per cent of the capacity, or 2,194,000,000 gallons is contained at an elevation above seventy feet, and if that portion only of the reservoir were utilized, and the water conveyed to Honouliuli, it would command all the irrigable land below fifty feet elevation, which is about 2,200 acres including Waimanalo.

The watershed area is about 16,500 acres. With an average of three feet of rainfall drained off this area it would furnish water enough to fill the upper thirty feet of the reservoir 7½ times during the year. If it were filled but once a year it would irrigate 550 acres. If it were filled four times a year it would water 2,200 acres. This is about what we think is reasonable to expect it might do; and if that assumption be correct it would afford cheaper water than could be obtained by pumping.

If the dam and conduit to the lands cost $242,000, it would represent an expense of $110 per acre on 2,200 acres. This would be a reasonable estimate for the cost, unless unforeseen difficulties should be encountered in the foundations. Our estimate shows the cost of a pumping plant for 2,800 acres to be $300,000, or $107 per acre. The delivery of water from the dam after it was once properly constructed would be comparatively inexpensive—very slight as compared with the constant expense of pumping.

All things considered, the gravity works would be decidedly preferable. All depends, of course, on the annual flow of the stream, and its distribution in such manner as to fill the reservoir every three months. Any failure or irregularity in that flow would tend to diminish the duty of the reservoir and increase the average cost to the lands actually served by it. The importance of the subject is sufficient to warrant the construction of a weir in the stream where a record of its flow might be kept for a period of some months—long enough to give some assurance of what may be expected from it.

THE WAIKAKALAUA RESERVOIR.

A survey was made by Messrs. Allardt and Kluegel of a reservoir site on the Waikakalaua gulch, the dam site being located about 1,000 feet below the bridge on the Waialua road, at an elevation of 580 feet above sea level at base, and the reservoir extending above the bridge about three-fourths of a mile. The top of the dam as surveyed, will be 665 feet above tide, and the waters stored may be conveyed to the Honouliuli plains with about three miles of conduit, reaching lands below 500 to 550 feet elevation. The contents of the reservoir would be about as follows:

Elev. above sea level.	Area in square feet.	Total contents in gallons.
580	56,000	
600	550,000	22,725,000
620	1,475,000	98,662,500
640	2,775,000	258,037,500
660	4,325,000	524,287,500

This volume, if the reservoir be filled once a year only, would maintain a constant flow of 2¼ cubic feet per second, without allowance for loss by evaporation, which need not be regarded, as the living stream would probably be enough to supply it. The area of the watershed is about 4,500 acres, all above 600 feet elevation, and having an average rainfall annually probably exceeding ninety inches. Three feet in depth drained off the watershed would suffice to fill the reservoir nine times a year. As this amount is a reasonable quantity to expect, it is quite likely that the reservoir would be filled once every six weeks, as its filling would require but four inches drained from the entire watershed, which we judge is not ordinarily beyond reasonable expectation. On this basis, therefore, the reservoir may be considered equivalent to a reservoir of nine times its capacity filled once a year. This would afford a constant stream of twenty cubic feet per second, a supply adequate for 1,200 acres of sugarcane.

The dam would be formed of earth, of which a superior quality, well suited for the purpose is at hand. A dam twenty feet wide on top, with side slopes of 2½ to one on the upper side and two to one on the lower, would contain 157,500 cubic yards. Its cost should not exceed $125,000 to $130,000. Its length on top would be but 460 feet. The site for a dam is a favorable one, and the materials as good as could be desired.

The ordinary flow of the stream as we found it, is about one and one-half cubic feet per second, which is considerably less than the flow three miles above. This is in a season of drought, and is represented to be far below the normal flow.

If our estimate of the regularity and frequency of the filling of the reservoir is correct, it would appear to be a very desirable location for a work of this kind. But so much depends upon meteorological data which is not obtainable except by continuous and somewhat protracted observation, that we can only submit our figures with the proviso—*if*.

In this case, as in that of the Waiawa reservoir, we recommend further observation and measurement of the stream before definite plans are decided upon.

THE KAHUKU RANCHO.

This well known rancho occupies the extreme northerly point of the island, extending from the crest of the mountain to the sea, and from Waimea River on the west to Laie on the east. It is thirty-eight miles distant from Honolulu, either by the Waialua or the Pali road. Its position on the windward side, with high mountains rearing up rapidly from the level of the belt of valley land along the coast, gives it abundant moisture and clothes it in perpetual verdure. Cattle roaming over its hills and valleys are all fat and sleek, and water is bursting out in places all along the coast, generally near the foot of the hills, or about midway between the foothills and the ocean. Near the ranch house is a tract of 250 acres so full of springs that it has been fenced in to cattle, from the danger of being mired and lost. One of the largest of the springs is about 100 feet in diameter and forty feet deep. The general level of the land is about twenty feet above tide.

West of Promontory Point (a bold cliff putting out into the valley about midway of the rancho) this character of springs is met with at intervals nearly all the way to the Waimea River. East of the point there are fewer springs on the surface, but the large artesian well bored by Mr. Campbell in the center of a large field of rank Bermuda grass, indicates that water exists abundantly below, and only requires to be tapped to yield all that may be required. This well has a very strong flow, which we estimated roughly at 800,000 to 1,000,000 gallons daily, although we had no means of measuring it accurately. At the Mormon settlement of Laie, adjoining Kahuku on the east, are a number of flowing wells giving a strong volume of water.

The area of valley land available for sugar or rice culture is between 4,000 and 5,000 acres, all lying below fifty feet elevation, and mostly lower than twenty-five feet. The flatness of the land renders it specially adaptable to rice, and more easily irrigable for sugarcane than land of steeper slope, while its low elevation would cheapen the cost of pumping.

There can be no question, we think, of the abundance of the water supply available by development of the springs, and by boring artesian wells, for any plantation that might be started upon the lands; and this we think would equally impress the most casual observer.

The rainfall being so much greater than at Honouliuli, the water needed for irrigation would be very appreciably less, and on account of the low lift the cost would be much diminished. We should not expect the cost of water for sugarcane to exceed $10 per acre per annum.

The pumps used here would probably be of the centrifugal pattern, on account of their simplicity and cheapness, and because the low lift would admit of their use with reasonable economy.

The soil of the Kahuku lands seems of the best quality, wherever the coral does not outcrop, and taken all in all the transformation of Kahuku into an extensive sugar plantation would appear to be an extremely simple proposition, with all doubtful questions eliminated, and expense of irrigation reduced to the minimum. The use of the low lands for this purpose need interfere but slightly with the utility of the rancho as a stock range, as good feed abounds in the hills and higher valleys as well as along the coast.

Although not pertinent to the lands treated of in this report we may mention incidentally that *en route* to and from Kahuku we made measurements of water as follows:

Waimea river	8	cubic feet per second
Springs east of Kawailoa river	25	" "
Kawailoa river	60	" "

Each of the two branches of the Waialua River apparently carries a larger stream at the road crossing that the Kawailoa, but they were not measured. Their flow is augmented by springs above the road, ten or fifteen feet above sea level. We conclude that in the vicinity of Kawailoa ranch near sea level more than 100 cubic feet per second of unused water may be made available for irrigation and profitably pumped to the high lands for use in sugar culture.

In making these examinations we have been impressed with the fact that there is great need for a systematic study of the water supply available for irrigation throughout the islands generally by experienced hydraulic engineers—and the collection and publication of just such data as we have been groping for very much in the dark. This is a work which should properly devolve upon the Government, and is undertaken and regularly and continuously carried out in almost every other civilized country where irrigation is practiced.

Where water is so valuable as it is here it would seem to be quite worth while to take an account of stock occasionally to ascertain what you have, what is done with it and what further good it can be made to accomplish.

In closing this report, already too long, we wish to assure you that we can fully substantiate every statement you have made to us prior to our investigation, regarding the lands and the available water supply, and we can cheerfully add that in our opinion it is feasible and within your power to irrigate a very large area of the dry Honouliuli plains, and at a reasonable cost, from the sources of supply within your reach, and that all of the coast valley lands of Kahuku, exceeding 4,000 acres, may be readily and cheaply irrigated from the water supply directly at hand.

The advantages apparent in the location of both Honouliuli and Kahuku for sugar plantations over all others on the island is in the fact that the Oahu Railway, already graded almost to the limits of Honouliuli, and projected to reach Kahuku, will allow shipments to be made directly from the plantations to the principal port of the islands, enabling the sugar to be placed on shipboard at Honolulu from the cars without expensive transhipment, re-handling and literage, and giving equal facility and cheapness in the transportation of heavy machinery, lumber and supplies to the plantations. This is an item of saving whose importance cannot fail to be appreciated.

All of which is respectfully submitted,

JAS. D. SCHUYLER, *C.E.*
G. F. ALLARDT, *C.E.*

Honolulu, August 26, 1889.

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CLAUS SPRECKELS' SUGAR REFINERY IN PHILADELPHIA.

PHILADELPHIA, November 4th, 1889.

Scarcely eighteen months have elapsed since Claus Spreckels determined to erect a sugar refinery in Philadelphia. Having made up his mind to do so, no time was lost in preparing the plans and letting the contract for the work. It was on August 4, 1888, less than fifteen months ago, that the first brick of this new structure was placed in position, and the corner stone was laid on October 29, 1888, just one year ago. It was then very freely intimated that fully three years would be occupied in the completion of the buildings, but this has been done in less than fifteen months, and to-day the Spreckels sugar refinery in Philadelphia was started into operation.

THE BUILDING SITE.

The site on which the buildings stand is situated between Reed and Dickinson streets, on the bank of the Delaware river. It covers in all nine acres of ground, exclusive of the space covered by three large wharves. The works are built upon sedimentary or made ground, the whole weight being carried by piles, of which there are more than 10,000. These piles are forty feet long, driven in clusters of twenty, with crosscaps and cement filling at the surface, which binds the whole in a solid mass. The masonry extends about twelve feet below the surface of the ground, requiring total excavations amounting to 20,000 cubic yards. The main buildings are 120 feet high. The walls begin with a thickness of thirty-eight inches, and all this immense weight, with tens of thousands of tons of iron posts, girders, concrete floors and machinery, have not settled the work one fraction of an inch.

SOME LARGE STRUCTURES.

The buildings now completed consist of the warehouse, 155 feet long by sixty feet wide, having an area of 18,000 feet; the finishing house, eighty-three by seventy-five feet, with an area of 12,782 feet; the char filtering houses, each 152 by sixty-eight feet, with a total area of 41,344 feet; the pan house, 157 by sixty feet, with an area of 18,870 feet; the boiler house, 265 by fifty-eight feet, with an area of 19,000 feet; the bag filter house, 166 by sixty feet, with an area of 9,900 feet; the machine shops, 200 by seventy-five feet, with an area of 10,000 feet; the barrel factory, 250 by 130 feet, with an area of 25,000 feet. Besides these are the offices for the engineer, the superintendent and the staff of clerks, the laboratory of the chemist and his assistants, and the building for the electric light plant and machinery.

SOME INTERIOR ARRANGEMENTS.

An idea of the immensity of the work may be gathered from the fact that fully 20,000,000 of bricks have been required in the construction of the buildings, which range from three to thirteen storys high. The pan house contains four vacuum pans, weighing 720 tons, with an aggregate heating surface of 14,800 square feet. In this building alone there has been consumed 1,000 tons of wrought iron and 650 tons of cast iron. The finishing house contains 250 tons of wrought iron work and 180 tons of cast iron; the boiler house 850 tons of wrought iron and 250 tons of cast iron; the filtering houses 2,200 tons of cast iron and 1,600 tons of wrought iron. There are ninety-six char filters, weighing 2,000 tons, and forty-eight char wash tanks, weighing over 900 tons; also forty-eight char kilns and retorts containing 2,000 tons of iron.

HANDLING THE COAL.

The steam generating plant is most important as well as being most expensive. The boilers are the Babcock & Wilcox, of the water tube type, divided into a number of separate batteries, amounting to 7,500 horse power. Every known improvement to economizing apparatus has been employed, and the coal is elevated by machinery to a storage bunker, situated above the boilers, whence it is delivered by chutes to the Roney mechanical stokers and by these automatically supplied to the furnaces. The spend coal, or ashes, as made, are mechanically conveyed to an elevator and delivered into an elevated receiving bin from whence they are discharged into railroad cars on either side of the boiler house.

THE BARREL FACTORY.

The barrel factory, which will be able to turn out 15,000 barrels daily, is the largest and most completely equipped in the United States. It is three storys high, with dry kilns, boiler and engine room independent of the main buildings. As many as 2,000,000 staves can be placed in the drying kilns at one time, the blowers for circulating the hot air being driven by a separate engine. Conveyors are arranged to automatically carry the barrels from the factory to the finishing room. A large quantity of cooperage stock is now on hand, and several hundred car loads are now on the way from the West.

The actual total cost of the whole of the buildings, machinery and site has not been definitely stated, but it is safe to assume it will amount to more than $3,000,000.

THE WHARFAGE ACCOMMODATION.

Running on to the refinery property are three distinct lines of railroad, forming direct communication with every section of the country. On the river are three wharves, each eighty feet wide and 600 feet long. Here a dozen of the largest sized ships and steamers can load or discharge at the same time, there being ample depth of water at the lowest tide. The wharves are covered in, forming immense warehouses, where the raw sugar can be received and stored in or delivered without handling into the melting pans. A conveyor runs along the whole length of the dock, carrying sixty tons of sugar to the pans at a speed of eighteen feet per minute. The whole of the buildings are lighted with incandescent lights of the Westinghouse alternating system, supplied from a central station on the ground. Automatic sprinklers for protection against fire are distributed throughout the buildings, and everything has been done to make the Spreckels Sugar Refinery in Philadelphia the best equipped and most economically worked, as well as the largest in the world.

THE REFINERY OFFICIALS.

The whole of the plans and the drawings for the immense refinery buildings were prepared under the direction of Mr. T. H. Maller, who remains as engineer in charge of the works. The work of construction has been carried on under the immediate supervision of Mr. Charles Watson, who has been Mr. Spreckel's chief engineer for twenty-five years, and who will shortly return to California to prepare for the erection of a number of beet sugar factories and to superintend other business that needs his direct attention. The Superintendent of the refinery is Mr. A. L. Seighortner, Jr., who will be directly responsible for the work of refining the sugar. Dr. A. Von Wachtel of Austria refinery chemist. Allen B. Rorke, the contractor, is so well known in Philadelphia that it is scarcely necessary to say that he has done the best of work with the best materials, and carried out his contracts to the letter.

THE BUSINESS OFFICES.

The business office of the Spreckels Sugar Refinery is in the four-story building situated at the northeast corner of Water and Chestnut streets, a location best situated for brokers and the wholesale grocery trade. Entering on the ground floor is the salesroom, running the whole length of the building. This is fitted up for the display of samples and for the convenience of brokers and buyers, and it is under the charge of Mr. C. E. Vail, who has represented the California Sugar Refinery at all Missouri River points for the past seven years. At the rear of the salesroom is a convenient office for the clerical work of this department, under Mr. Percy E. Guard. On the second floor, at the front of the building, are the private offices of Mr. Claus Spreckels, Mr. C. A. Spreckels and Mr. Rudolph Spreckels. From these one passes into the correspondence department, under the supervision of Secretary C. R. Buckland. This room is directly connected by electric bells with the various telegraph offices of the city, and is perfectly equipped for accomplishing the largest amount of work in the least possible time. A corps of half a dozen lady stenographers and type writers, busily engaged at their work, reminds one of the incessant clicking of a large telegraph operating room. On the third floor is the bookkeepers' department under the supervision of Mr. George Stimpson, and here the large safes and big ledgers remind one again of the extensive business in hand. The offices throughout are equipped with every convenience and handsomely furnished, as becomes an institution of this character.

DUPLICATING THE WHOLE PLANT.

Most people would be satisfied with a manufacturing establishment of the size just described, that can handle and refine 2,000,000 pounds of sugar in every twenty-four hours, but Mr. Spreckels is not a man of the every-day kind. He wants something a little better than anybody else, so has decided to duplicate the whole of the buildings now erected and in operation. This will give this refinery a capacity of 4,000,000 pounds or 2,000 tons of sugar every twenty-four hours. Work was commenced on the duplication of these buildings a month ago, by the erection of a dividing fence, so that the new work now in progress will not interfere with that which is completed. It will not take so long to duplicate the buildings and machinery as it did to erect the first half of them, because all the plans are prepared, estimates of values have been arrived at, machinery patterns have been made, besides a number of other matters wherein experience has been gained, so that Mr. Spreckels looks with confidence to the final completion of the whole plant, with its daily capacity of 4,000,000 pounds, before the end of next year.

A SOLID ENTERPRISE.

When all this is finished there will be a solid mass of buildings extending from the Delaware River for three squares to Meadow street, and from Reed to Dickinson streets. There will then be found constant work for about 1,000 persons in this city, which makes, indeed, a solid and permanent enterprise established in Philadelphia. While looking at the immense structure this morning, it seemed almost incredible that only a short time since there was nothing here but a vacant space of land, while to-day everything is bustle and activity, from the wharves where the sugar is being landed to the barrel factory in the rear of the big building, where the barrels are being made to contain the refined sugars.

SUCCESS TO SPRECKELS.

Besides the five or six millions of dollars circulated here through the construction of the buildings, there will be permanently employed an army of skilled workmen who have their homes here and who will distribute their wage earnings among our retail trade. There will be increased business for our railroads and a considerable addition to the shipping arrivals at this port. It would be a good thing for Philadelphia if more men could be found like Mr. Spreckels, and he has indeed our best wishes for his success in his undertaking.—*Corr. S. F. Post.*

A SUGARLESS WORLD.

A world without sugar can hardly seem a place worth living in to the juvenile mind. Farewell to jam in limited or unlimited allowances, to schoolboy raids upon the pantry, to savoury puddings and dainty cakes, to lollipops, rhubarb tart, and gooseberry fool! Blessings on the man who discovered the art of extracting sugar says the housewife who dare not contemplate the cuisine of a world literally without sugar. Blessings! reiterates the boy, with his mind dwelling on the preserve pots of Egypt. By his discovery he has diminished the sum total of wry faces among his fellow creatures. He has added a certain charm to the juvenile drug; at least, he robbed it of more than half its terrors. The aged crone of three generations ago who chewed her soaked tea-leaves, not knowing how to use them, must have longed, like Faust, for a new lease of life when she became initiated into the real luxury of the tea-pot, and the sweetening influence of sugar upon her new beverage. The raw school-miss, whose swollen cheek would suggest a bad attack of neuralgia, were it not that she has just paid a flying visit to the nearest confectioner's has reason also to bless him. And yet the world neither knows his name nor his native land. It is probable that he was some nude Indian or some lightly clad Chinese who lived hundreds of years before the march of Alexandria. But, whoever he was, he went with his painted face or his pigtail to his flaming pyre, or humble six feet of earth, "unwept, unhonored and unsung." Had he been a Greek, he would have been the theme of as many legends as Hercules; had he been a Roman Emperor, he would have been turned into a constellation or a god. Had he been an Englishman, he would have got £5 for his discovery, somebody else would have walked off with the profits of his inventions, and he himself would have been allowed to die of starvation. His epitaph might have been some bootless question in the House of Commons as to whether he had not a right to a memorial slab at least, if not a grave, in Westminster Abbey.

One might be sometimes tempted to wonder if Shakespeare ever really tasted sugar, were it not that he has a very few references to it. Most of them point to its sweetness. Chaucer also uses the word; so does the author of Pier's Plowman. We do not know if it can be traced much farther back in English literature. One of the very earliest, if not the earliest known reference to it in connection with this country is made by a Venetian merchant who, in 1319 shipped 100,000 pounds of sugar which had been brought from the Levant, and 10,000 pounds of sugar-candy to England to be exchanged for wool. This was about forty years before the dreaming Monk of the

Malvern Hills had satirised in Pier's immortal vision the vices of his time. The English Crusaders made its acquaintance in Sicily, Crete and Syria, into the two former of which places, at least, the Saracens had introduced the sugarcane. Then Venice, which had been importing a little sugar from the tenth century, became the center of trade in the costly luxury, and remained the headquarters of such trade as there was until the Spaniards introduced the cane into the West Indies. It was by means of the tax which Charles V. levied on the sugar imported into Spain from San Domingo that he was enabled to build his palaces at Toledo and Madrid. All this means that except at a few favored points, sugar was utterly unknown all over Europe. Celt and Saxon, Englishman and Dane, Scandinavian and Norman, all had stormed their way into this little island of ours without ever having seen or heard of sugar. They had left their Aryan home before the sugarcane was first munched between Aryan teeth amid wah-wahs of delight and enjoyment by their Aryan brothers in the valley of the Ganges. They brought no name for sugar with them; the thing was unknown. The name does not seem to come into existence till that unknown man of genius to whom we have referred, discovered the art of squeezing the juice out of the cane and boiling it, and giving the product the name of sugar—that is "granules," or, as a scientific age would now say crystals. Not till after many ages did the name given to it by their remote brothers in the Gangetic valley come to the European peoples through the Persian and the Arabic—*shakar*, *sakkar*, *Anglice* sugar. In many parts of Scotland it is at this moment called *sukkur*. The earliest mention of sugar in the whole literature of Europe occurs in the year 320 B.C., when Theophrastus describes it as a honey extracted from canes or reeds. He had not heard of it as "granules," but as a syrup or juice merely. Strabo, on the authority of one of Alexander's Admirals, tells that certain reeds in India yielded honey without the aid of bees. Here again, Alexander's Admiral had only known of it as a syrup. Seneca had heard a story that honey was found in India on the leaves of reeds, but the story was quite wrong, as the juice does not exude naturally, but must be crushed out of the cane. Again, he also had heard only of the syrup. Pliny also had got hold of the wrong story—that it exuded as a gum—and he fancied that the gum hardened on the stalks into pale and brittle lumps—large "granules"—about the size of a hazel nut. This, however, was sugar-candy, not a naturally hardened exudation, but a work of art. The grand old man's discovery of boiling the juice of his sugarcanes had at last penetrated into the Greek and Roman world. What had the Greek housewife done all this time without it? If she had

had it, would the Greek poets have sung of it in the same lofty strains in which they have immortalized the honey of Hymettus?

The only sweetener before the introduction of sugar was honey, and our Scandinavian fathers, like the Greeks, have embalmed its glories in legend and song. But unless bees were infinitely more numerous than they are now-a-days, honey also must have been a rare luxury. That it was a luxury is evident from our Teutonic word "honeymoon," which is derived from the custom of drinking diluted honey for thirty days after marriage. Honey, in any form, can hardly have been in daily use even among the great, or surely Attila would not have drunk so much hydromel on his marriage day as to die from the consequences. The mass of the European people may be said to have been utterly without a sweetener until the increasing use of tea and coffee in the eighteenth century gradually converted sugar also into an article of food. In 1700 the amount of sugar used in Great Britain was 10,000 tons, which was equal to an average of a little more than three pounds per head of the population per annum. This would give as much sugar per day to each inhabitant of England, Scotland and Wales as a person might lift with moderation between the forefinger and the thumb. What a wretched allowance! In a list which formed the food of agricultural laborers in 1765, given in the *London Magazine* for that year, neither sugar nor tea is mentioned; but in a similar list given by Sir F. Eden for 1796 both are allowed. It is obvious that most of the grandmothers of the somewhat elderly members of the present generation never had their childish fits of waywardness mollified by any preparation of sugar. A hundred years ago the article must only have been beginning to be known in the smaller towns of England and Scotland. In 1796, Sir F. Eden's year, when the little Carlyle was making his parents' nights wretched with the atrabillious squalling of his infantile genius, the enterprising grocer was, no doubt, still in the prime of his life, who first ventured to introduce it to the gossips of Ecclefechan. Burns, as a child, probably never tasted it; and when the little lame Wizard-boy of the North lay on his lonely hillside of the Scottish border, staring into the sun, with his childish brain already seething with the legends and romances of his native land, you might have traveled through all the villages from Galloway to Tweed-mouth and asked for it almost in vain. So it was with gallant little Wales and the English Midlands. Could the ghosts of our great-grandmothers rise, not one of them would understand how it is that Sir W. Harcourt was lately making so much fuss about the Sugar Convention. Why, beet root sugar, which he has taken under his care, was only discovered a hundred and forty years ago, and nobody could extract it so as to make it pay until the beginning of the present century.—*Evening Standard.*

STEAM PIPES.—SIZE OF STEAM PIPES—AREA AND EXPANSION—STEAM BOILER PIPING—SPECIFICATIONS—SETTING BOILERS.

The question "how big is a piece of two-inch steam pipe?" sounds much like "how long is a ten-foot pole?" but the answer is different. To the latter the reply is, "twice the length of a d—n fool and take yourself for a measure," but to the former question the correct answer is 2.375 inches outside diameter and 2.067 inches inside measurement.

Bolts, nuts and thread have been pretty well standardized during the last twenty years, but the sizes of steam, gas and water pipe were made first as they now stand. A piece of ⅛ steam pipe is more than a quarter of an inch in diameter, being .27 inches inside and .68 inches thickness of metal, giving an outside diameter of .406 inches, much larger than its name, ⅛-inch. This pipe is cut with twenty-seven threads per inch and will just slide easily through a hole bored with a 7-16 inch bit.

Pipe called "¼-inch" is over 5-16-inch in diameter, being .364 inside diameter, .54 outside diameter and .088 or 3-32-inch thickness of metal. Pipe known as "⅜-inch" is about ½-inch (.494) inside diameter and .675 outside; ½-inch pipe has respectively diameters of .623 and .84 inches; ¾ pipe has diameters of .824 and .105 inches, while standard one-inch pipe is 1.048 inches outside diameter and 1.315 inches outside size. One and a quarter-inch pipe comes next, with a diameter of over 1⅓ inches (1.38 inches) and 1.66 outside diameter; 1½-inch pipe measures 1.611 and 1-9 inches and will slide easily through a two-inch auger hole; two-inch pipe, 2.067 and 2.375 inches; 2½-inch pipe, 2.468 and 2.875 inches; three-inch, 3.067 and 3-5 inches; 3½-inch, 3.548 and four inches; four-inch, 3.026 and 4-5 inches; 4½-inch, 4,808 and five inches; five-inch, 5.045 and 5.565 inches; six-inch, 6.065 and 6.625 inches.

As before stated, the ⅛-inch pipe is cut with twenty-seven threads to the inch, and ¼ and ⅜ pipe is cut with eighteen threads, ½ and ¾-inch pipe has fourteen threads, one, 1¼, 1½ and two-inch pipe have 11½ threads per inch, and all sizes larger, up to ten inches in diameter, have eight threads per inch. In calculating the areas of pipe all that is necessary is to multiply the diameter by itself and by the decimal .7854. This fraction represents the ratio of a square, to a circle that can be exactly inscribed within that square, hence a square just one inch on a side, will contain exactly one square inch of surface, but if a circle be drawn inside, and touching the sides of the square, this circle will contain but .7854 of an inch area; hence to find the area of any circle find the area of a square having sides equal to diameter of the circle, then for each square inch of surface, in that square, there will be .7854 times as much in the circle whose diameter is the same. In other words, the circle contains nearly three-fourths as much as a square which will just contain the circle. .7854 is the exact figure, and squaring the diameter of any circle, then multiplying by this fraction, will give the desired area. It is easy to remember this fraction, as it is exactly one-fourth the ratio of diameter to the circumference of a circle, or 3.1416. This well known mixed number is called "pi," and if either fraction be forgotten it can be brought to mind by using the factor four in connection with the number brought to mind. The areas of pipe are as follows, giving both inside and outside measurement in square inches; $\frac{1}{8}$—.0572 and.129; $\frac{1}{4}$—.1014 and .229; $\frac{3}{8}$—.1916 and .558; $\frac{1}{2}$—.3048 and .557; $\frac{3}{4}$—.5333 and .866; one-inch—.8627 and 1.357; $1\frac{1}{4}$—1.496 and 2.164; $1\frac{1}{2}$—2.038 and 2.835; two—3.358 and 4.430; $2\frac{1}{2}$—4.738 and 6.491; three—7.388 and 9621; $3\frac{1}{2}$—9.887 and 12.566; four—12.730 and 15.904; $4\frac{1}{2}$—15.939 and 19.-625; five—19.990 and 28.299; six—28.889 and 34.471.

From an inspection of the above figures are as their respective diameters, it will be seen that the capacity of pipe increases as the squares of their diameters; therefore, two one-inch pipes are not equal to one two-inch pipe, but it will require four one-inch pipes to carry off all the water delivered by one two-inch pipe, to say nothing of the increased resistance of a fluid in the smaller conduit.

The larger the pipe the nearer does its inside diameter approach to its named size, and in the smaller pipes this difference is the greatest. This fact is taken advantage of to make the necessary allowance for friction when arranging systems of piping. For instance: If a one-inch pipe is to supply a certain number of $\frac{1}{8}$-inch branch pipes, considerable allowance must be made for the increased friction of the smaller pipes, and the extra size of the smaller sizes gives leeway enough for this purpose. The area of a one-inch pipe should be .7854 square inch, but as the pipe is actually 1.048 inches inside diameter its area is 0.8627 inch.

In calculating the number of $\frac{1}{8}$-inch pipes necessary to equal the delivery from a one-inch pipe, we will call the larger pipe exactly one inch in diameter and the smaller ones precisely one-eighth inch each. According to the square of their diameters theory it would require sixty-four of the smaller pipes to drain the one-inch one. This is all right in theory, but to force the water through all those small tubes would require enormous pressure, or an increase in their number; therefore the ⅛-inch pipes are made over ¼-inch inside diameter, and are therefore abundantly able to take care of the quantity delivered by the one-inch pipe.

A graphical and very handy way of comprehending the above statement is to draw upon a board, or paper, a square ⅛ inch upon a side, to represent the smaller pipe, then from one corner of the square, and enclosing it, draw a larger square having a side just an inch wide, and representing the one-inch pipe. It will be perceived that sixty-four of the small squares are necessary to equal the one larger one.

The above can be varied to suit all cases. If a three-inch pipe is to be branched up to supply several smaller ones, the limt to branches can be quickly determined by drawing a three-inch square, and cutting from it a number of squares equal to the area of pipes the large one is to supply. From the three-inch pipe a two-inch one is taken out, then two one-inch pipes, and three-fourths inch branch. Is this too much? Will the three-inch pipe supply them all? The divided square will tell quickly and truly that there is still room to spare in the three-inch pipe. Draw a square three inches on a side, divide it into nine equal parts, by square one inch long and wide. The two-inch pipe takes out four squares from one corner of the large figure. It seems to take away the most of it, on first sight, but a count reveals that while four squares are gone five are left, or more than one-half. The two two-inch pipes remove a square each, leaving three squares remaining. The ¾-inch pipe takes 9-16 of one square, leaving supply capacity remaining sufficient to supply two one-inch pipes, one ½-inch and three ¼-inch pipes! Truly, the capacity of a pipe increases tremendously with a slight increase of diameter.

Piping so erected that it has no chance to expand or contract is sure to break something when heated or cooled. Wrought iron expands .00150 of its own length for every degree of heat, within limits, the steam user will not exceed, and, small as this amount seems, it becomes considerable when steam pressure is high and the pipe long. When a pipe 100 feet long is run in a small, narrow space, or is such size that it will not spring sideways, the elongation will be .08 inch for each degree of heat. When seventy pounds pressure (for steam gauge) is used the temperature of steam will be about 315 pounds. Taking from this the temperature of the atmosphere, or sixty degrees, 255 will remain to be used as a factor with .08 of an inch. To determine the entire elongation of the pipe .08×255

=2.04 inches, the actual elongation or expansion of 100 feet of pipe when heated with live steam of seventy pounds apparent pressure.

Steam pipe expanding under the above conditions is capable of exerting a pressure of twenty-five to thirty tons, and it can readily be seen that if nothing else gives way the pipe or fittings must be destroyed or the thread stripped from fittings or pipe. The same thing will take place should the pipe be placed in hangings which can catch the pipe and prevent it sliding back and forth.

When steam boiler piping and connections are placed under ground they give way in expectedly short times. It is not generally known that coal ashes are very destructive to iron pipe when exposed to moisture, but such has been found to be the case, especially by workmen of the New York Steam Heating Company. Lime is also a very destructive agent to buried pipes, and old morter contains much lime.

In most cases where feed pipes have given out, they have been buried in the ground, and in many cases, both lime, cinder and moisture have been agents in the destruction. If pipes for boiler feeding must be buried, make them of brass. If the labor of keeping brass piping bright is objected to, give the piping a coat of black asphaltum varnish and there will be no trouble on that account. If iron feed pipes are used and put overhead, or anywhere out of the ground, they will out-last the boiler itself, but if they must go underground, use brass at least for the buried portions of the pipe.

Speaking about piping a boiler for feed water, brings to mind the haphazard way in which such work is often done. The piping often is left to the journeyman piper, and in that dignitary's absence his "cub" takes a hand in locating valves and connections. Every pump ought to be so connected and cross-connected that it can be used to the work of every other pump in the room.

Sometimes pumps are set up near by for other purposes than boiler feeding; in this case connect them altogether so the work can be interchanged at will. It only requires another valve and one or two pieces of pipe, but it may save much trouble in case of emergency.

Every feed pump should have by-pass connections, whereby it could be gauged to deliver any required amount of water within the pump's capacity, without altering the speed of the pump. It can be done by connecting the supply and delivery pipes with each other, and placing a valve in the connecting pipe. All the pipes used underground to be brass, others wrought iron with heavy cast iron fittings. Wrought iron fittings will stand more strain than cast iron, but in case of repair it is tedious work to get the piping to pieces. A blow with a hammer will break off a cast iron elbow, and the cost of the fitting is less than that of time spent in taking apart pipe with wrought fittings, to say nothing of the possible damage to the pipe and thread.

When unions are used they also, should be made of cast iron, and unions ought to be used on all pipe over two inches, while right and left couplings should be put on piping less than 2½ inches. When rights and lefts are used, always cut the left hand thread on the shortest piece. In this way, a man always knows how to put on the pipe tongs in order to start the couping in the desired direction.

Expansion joints ought to be avoided whenever possible. By putting an angle in the pipe the expansions can be taken up by the spring of the pipe. Never allow less than eight feet on a line of two-inch pipe, 100 feet long, on twelve feet for the same amount of three-inch pipe, other sizes in proportion.

A uniform kind of valve should be used throughout a piping job. Nothing detracts from a job so much as two or three kinds of valves. Sometimes it is dangerous. In case of emergency for a man to get hold of a valve different from those he is accustomed to does not add to his presence of mind. With one kind of valve used throughout the entire job the result is all that can be desired.

When connecting radiators, all having over eighty square feet of heating surface, should be supplied by 1¼-inch pipe and valves, and one-inch return connections, over forty feet and less than eighty, the steam pipe and valves to be one-inch, the return three-fourths inch. All smaller radiators less than forty square feet of heating surface should have three-fourths inch steam and one-half inch return valves.

Setting steam boilers, like piping pumps, is too often left to the local talent who may be employed to do the work. Sometimes this leads directly to trouble. At other times economy of fuel surfaces and a poor steaming boiler is the result. Never hurry a boiler setting job by putting on a lot of men and rushing it. Better take a little more time and let two good masons do the job, and even then have it done according to the engineer's plans, not as the local mason says "in the best way."

Never set even a six-foot boiler with less than a twelve-inch wall; that is for horizontal boilers, for the loss of heat by radiation is much greater with a thin wall, and the discomfort to the attendants is also much greater. When small boilers are set make the walls twelve inches, including the fire-brick For large boilers twelve inches excepting fire-brick, and the largest boilers should be set with twenty and twenty-four inch walls, fire-brick lining not included.

Settling the foundation is the unusual cause of the ungainly cracks often seen in boiler settings. By some people this is attributed to the unequal expansion of brick, the inner ones expanding the most, but this is not so. Any cracks caused by this can be closed by a coat or two of whitewash. Big cracks never come from brick expansion; and again, the hotter a brick becomes the smaller it becomes after a certain degree of heat has been attained. To avoid this cracking of the setting a good foundation is necessary. If the ground seems soft, dig a hole the whole size of the brickwork and put in twelve to twenty-six inches of concrete upon which the brickwork may be commenced.

Never permit the lugs to be bricked in firmly. If this is done the boiler in expanding will surely tear apart the brickwork, and injury may be done to the shell by the immense power exerted by the expanding iron. The lugs should be placed on pieces of round iron, which in turn rest upon pieces of flat iron set in the brickwork. A cavity to be left over each lug and at its end gives room for the necessary expansive movement of the boiler.

Four lugs, so put on as to divide the weight of the boiler, seem better than six lugs, as with the greater number, there being three on each side, the foundation chancing to settle, gives two of the lugs the weight that should be divided among three bearings, and not being located to carry all the weight of boiler and its contents the result may be weakening of the boiler.

When a brick arch is to be built over the boiler, under no circumstances whatever, allow the bricks to be laid directly upon the shell. The lugs and plates to which they are attached already have sufficient load to carry without adding a ton or two of bricks and morter. If an arch must be built, lay a lot of 1½ or two-inch strips of wood on the boiler, lay a course or two of brick, then pull out the strips. This leaves a space all around the boiler, which is the greatest objection to the method.

A much better way is to build the walls straight up, to a point about the top of the boiler, then put dry ashes between the walls until the boiler is covered to the required depth. By this method the outside of the shell may be got at at any time without digging through a brick arch. The ashes should be sifted, to remove any pieces of charcoal they may contain, and which might become ignited and lead to a "mysterious fire." Like many other things, setting a boiler requires a good deal of knowledge, and more than is usually held by the local artists of the trowel. It is well to have a plan, then work to it.—*Tradesman.*

IRRIGATION APPLIED TO GROWING CANES, READ BY MR. R. VITERBO BEFORE THE LOUISIANA SUGAR-PLANTERS' ASSOCIATION, JULY 11, 1889.

The cane on account of its peculiar constitution and of the circumstances required by the functions essential to its organs, needs constantly a certain degree of moisture in the soil to keep up a healthy condition. I will try to demonstrate how important is the concourse of the water in all stages of vegetation of our staple in order that its organs might be able to undergo all their evolutions until complete growth is reached.

When a stalk of cane is buried under dry earth, if there are no opportune rains, the eyes instead of sprouting will dry up and will die so much quicker if the stock be soft, short or less covered with dirt. It is impossible for the eye to sprout without any moisture.

When the eyes have sprouted, and when the cane comes out of the ground, if it does not have the benefit of the water, in a short time its leaves fade and after a while the plant dies.

If the rain fail when the cane commences to make its joints those joints do not shape well, they are shorter, the eyes are nearer to each other, the percentage of woody matter is largely increased; the leaves are fastened together and the cane looks as if it were surrounded by a straw sheath, as sometimes happens, when the grass is not destroyed on time in a field. The cane does not grow, not only because it fails to receive the aliments that its roots ought to take from the soil, but also because the reactions which must happen in the leaves and through the shell cannot take place at all; the leaves dry up more or less, and the cane will at last disappear. We must say, however, that the plants do not suffer to the same extent from the drouth in all the varieties of soils.

There are some soils which, even in dry weather, seem to always keep some moisture, and the plants look there as if they have had the benefit of continuous rains. These soils are very seldom found, but any one has been able to remark this year the difference in the injurious effects of the drought in the various parts of his fields. In the stiff lands the cane has differed to a great extent, and in some places it is a pitiful sight, even now, after the copious rains of the last part of June, to see so much work done for nothing. In light soils the cane showed much more vitality, and then it is a joyful sight to notice how quick the plant has recovered from the effects of the drought. No one, however, can deny that the sight would have been much more cheering had we had some rain during the month of May.

If there be differences in the capability of the soils to retain their moisture according to their composition, there are greater differences in the same soil according to the way that it has been prepared and to its drainage facilities.

At first sight it seems paradoxical to say that the better a soil is drained the longer it will retain its moisture, but nothing is more certain than the above proposition. In fact, for good drainage, it is necessary not only to have *plenty* of ditches and quarter drains to give a free outlet to the superficial rain-water, but also to have the thickest possible bed of arable soil to drain as deep as possible. Of course, in breaking the lands we must avoid going too far down for fear of mixing an arid sub-soil with our fertile upper bed. Every one understands that the deeper that upper bed is the greater will be its absorbing power for water and the less quickly it will be saturated. The thicker the arable soil is the more slowly it will dry under the influence of the sun and wind.

The eminent French agriculturist, Mr. Moll, has found by careful experiments, that, all other circumstances being equal, the time necessary to dry out a piece of plowed land from the surface down to the unplowed ground varies in inverse ratio to the square of the depth; that is to say, if we suppose that the arable bed is composed of different strata of an inch thickness, and if one hour of sun is needed to dry the first stratum, it will take four hours to dry the second one, nine hours for the third one, and so on. It is therefore plainly shown that the drainage and preparation of the soil are the two most important factors to be considered in every rational system of agriculture.

After this little digression let us go back to our precious grass and see how much water it contains in the last period of its growth. When the cane is brought to the mill it contains seventy per cent of water at least, and if we suppose an average crop of twenty tons per acre, we find that we take from the fields 20,000 pounds of water per acre. But that quantity of water is nothing in comparison with what is needed by the plant during the first period of its vegetation. It has been, in fact, clearly proved that the proportion of moisture absorbed by the leaves during their formation is far superior to that contained in the plant after its complete growth. Nazeli has shown also that a certain quantity of water is necessary for the formation of the cellulose. This water, however, does not remain in the cane; it is evaporated and constantly renewed, and if the cane were transparent one would be astonished to see the stream of water going through it.

We must now account for the water absorbed by the roots from the soil, which, after running through all the organs of the plant, evaporates by the eyes, and that tremendous absorption constitutes the most essential feature of all vegetation. The suction by the roots of all the necessary elements takes place on very diluted solutions and of course the consumption of liquid it considerable, the water being only the vehicle for the mineral elements taken from the soil and running through the cane to the eyes, where it evaporates into the air by perspiration.

If, after weighing the canes produced by an acre of ground, we could weigh also the quantity of water evaporated in the different phases of vegetation, we would certainly see that during its life the cane has absorbed many times its own weight of water.

If we add now all the water lost by the soil through the air by evaporation, we can easily understand how important it is to replace that element whenever we fail to have the required rains. The annual rainfall in Louisiana would certainly be more than sufficient for all the needs of our agriculture if the number of rainy days were not so limited and if they were more regularly distributed. In fact, the rains in this country are generally too copious and furnish an excess of water which is altogether lost. Sometimes there is too much rain and sometimes none at all; in both cases the cane is injured. We cannot find any remedy for too much water except to have a system of drainage as perfect as possible; but whenever there is not enough rainfall it is in our power to give our canes the much needed water, and the irrigation of our fields becomes a necessity for every thorough agriculturist, as nobody now-a-days doubts of the great utility of that work.

In almost all irrigation the water not only acts to keep up the degree of moisture required for the growth of the plant, but it also acts on the vegetation as an energetic stimulant, because in its natural condition it contains in solution some oxygen, carbonic acid, ammonia, nitric acid and mineral salts, without mentioning the solid matters in suspension, the value of which is universally appreciated.

The temperature of the water seems to have a great influence on the advantage which could be derived from irrigation; as a general rule the higher the temperature the more the plants are benefitted. That might explain the reason why some attempts of irrigation made in Louisiana have failed to give satisfaction. When the water is too cold, as the Mississippi river's at certain times of the year, before using it it must be left in contact with the air for raising its temperature, and nothing is easier than to let it stand in the open ditches during three or four days for that purpose.

In the summer of 1884, after a long dry spell, I made an attempt to irrigate some laid by canes (about 100 acres), and the result was very satisfactory. The canes after being irrigated in the middle of August, began to grow again with a new vigor, and by the time they were cut anyone could notice that, after a series of hard soft joints, due to the drought, there were from the middle of the length to the top another series of long soft joints.

These canes did not contain less sucrose than the other ones; they were much longer and a great deal less hard. The irrigation was practiced by submersion as in rice field. The water, after standing a few days in the ditches, was forced up in the middle furrows during the night and was taken out early in the morning before sunrise.

When a crop is laid by there is no inconvenience in irrigating by submersion, but when the cane is small there might be some danger in that practice, an excess of water being injurious to the plant, besides that the ground would be more or less packed in the rows and further cultivation would become difficult. Unless the topography of the piece of land to be irrigated is such as to allow a very rapid transit of the water in the middle furrows, I think that in case it is necessary to irrigate a young crop it must be done by sprinkling. One movable steam pump could be put on the head and land water could be thrown on top of the rows in sufficient quantity.

The *modus operandi* either for supplying the necessary water or for distributing it over the field will vary with the localities, and will depend on the means disposed of by each planter. Therefore, I will not go into the details of all the systems in use in the countries where the soil could not produce anything without irrigation.

Suffice to say that the planter who is convinced of the great advantage of irrigation, will have to be cautious and not spend any money for an expensive plant without consulting a competent man whose duty will be to make a careful study of the best plan to be adopted.

If I am allowed to express my personal opinion on this subject I will say that, sooner or later, irrigation will have to be practiced in Louisiana by a combination of artesian wells and tile drainage.

The wells bored in three or four different places on a plantation will give all the necessary water at an invariable temperature, and a special disposition of the tiles with vertical clay pipes would distribute the water all over the fields. The conclusion of this humble essay would therefore be: If you want to practice irrigation, provide first for the best drainage.

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The trade in birds for women's hats was so large that a single London dealer admitted that he had sold 2,000,000 of small birds of every kind and color. At one auction there were sold 6,000 birds of paradise and 400,000 humming birds.

THE IRRIGATION OF INDIA.

Successive famines in India, caused by drought, compelled the British people to seek some means of averting disasters which were the odium of British rule in that country. The reports of the Indian office show that in 1877-8 the loss of food products in the North western provinces from drought amounted to 3,420,000 tons of food grain, enough for a population of 21,000,000. In the ensuing famine a million and a quarter died of starvation. The lack of water caused therefore in India as great loss of life as its too great abundance has caused in China in the path of the Yellow River floods. The Indian Government began irrigation efforts in the Punjaub, where the greatest suffering had been. The report details the operations there and their cost and results. The system is peculiar in having perennial and flood-water facilities. The flood-water canals are used to produce one crop a year by using the surplus water for one irrigation. We suppose it is something like the winter irrigation practiced in some parts of Southern California upon orchards and vineyards. In this way an inundation is prevented, and the waters that might destroy as a flood are made to create as used for irrigation. It is quite worth while to note that recently Hon. Will Greene of Colusa has pointed out the necessity of providing inundation canals for the Sacramento River, not only for irrigation, but to draw off the silt which is continually raising the bed of that stream, and will finally put it on top of a ridge, from which it will jump off upon the farms below and repeat to a degree some of the destructive feats of the Yellow River. In addition to these flood channels the Punjaub has been provided with five great, permanent irrigation canals, which have cost $22,330,000, and irrigate a surface 1,210,667 acres in extent, which last year produced crops with a market value of $14,300,000, and returned in water rents 4 per cent on the capital invested in the irrigating works. The Punjaub, excuse the diversion to our old friends the Greeks, in the first syllable of its name has the Persian form of the Greek "pan" (all), and was so named because it had all the rivers which join the Indus. Its streams are: the Indus, Jhylum, Chenaub, Ravee, Sutlej, Punjnud and Beas. Above its great plains lies the Vale of Cashmere. The crops grown are food grain and the mango, orange, pomegranate, fig, mulberry, date, apricot, peach, apple, quince, almond and melon. It reads like a list of exhibits at a California State fair, and the similarity of the two regions is aided by the fact that a forest commission is planting, on the Punjaub plains, great groves of the eucalyptus from Australia, and the temperature seldom falls below 40° in the winter or rises above 112° in the summer. Quite isolated from the general commerce of the world, yet the irrigation of less than a million and quarter of acres produced more than fourteen millions and a quarter of dollars of value in one year of these crops. Evidently we can learn something "from many an ancient river and many a palmy plain" that will illuminate the American understanding upon the subject of our undeveloped resources. The longest Punjaub canal is 542 miles in length, and irrigates only 400,000 acres, charging half rates, and yet it pays the cost of administration and 4 per cent interest on the capital. There are numerous columns of statistics in this country to show that we have about 3,000,000 of idle, semi-indigent but able-bodied men. If true, this is a more serious reflection upon us than the Indian famine of 1877-8 was upon the British Government in the Punjaub.

By irrigation the famine-smitten Hindoos were enabled to produce their own food, and giving them the necessary facilities profitably employed over $20,000,000 of capital. Suppose that, the way being engineered by our Government under the enlightened policy originated by Senator Stewart, the investment of that much capital should render tillable a region in which our 3,000,000 idlers could raise their own food by their own labor, would not an increasing odium be removed from our institutions? Again, if Asiatics can so profitably use irrigation as to pay a better interest upon the capital creating it than our Government pays upon most of its bonds, cannot American labor do as well, and if so will there not be furnished a ready opportunity for coaxing from passive to active investment a vast deal of capital that is now in public bonds? We are persuaded that the application of flood and permanent irrigation works to the valley of California alone will increase the volume and value of its production by more than twice the yearly market price of the Punjaub crops, which stand between that people and famine. To return to Mr. Greene's idea: Canalage of the floodwaters of the Sacramento will carry the deposit of silt evenly over the valley, veneering it with the rich deposit, instead of raising a ridge to be finally deserted by the destroying river. Every river is a land-builder, and when its valley is densely settled, unless the processes of nature are guided so as to raise the floor of the valley evenly, there must be periodical changes in its channel, attended by devastation. Mr. A. T. Hatch informs us that a recent rise in a confluent of the Sacramento, due to the failure of a mining dam, fortunately found low water in the channel, so that an access of six feet was harmless. But had it occurred on top of the usual floodwater it would have inundated and destroyed a great area of young orchards and vineyards. It does not answer in matters of such gravity to trust to luck like that, and we should study together the history of overflows in the Yellow river and the results of irrigation in the Punjaub, and apply the lesson to the condition of our great valley.

PROSPECTIVE BEET SUGAR PRODUCTION IN THE UNITED STATES.

When we calculate to what gigantic proportions beet sugar production has been brought in Europe in recent years, by intelligent field manipulations and scientific methods of manufacture, it appears strange how apathetic our people are on the subject of home manufacture, when it is known that California alone has lands capable of yielding 500,000 tons of sugar per annum. The area adapted to beet culture extends from the Atlantic to the Pacific, and is simply immense.

The isothermal lines of required temperature and rainfall will curve according to the altitude above the sea level, etc., yet it will probably be found that these beets can be profitably cultivated in California, Washington, Missouri, Arkansas, Tennessee, Kentucky, Pennsylvania, Maryland, Virginia, North Carolina, South Carolina, Mississippi, Alabama and Georgia, a territory so vast that if required could supply hundreds of millions of people with sugar. If we do not become home producers, the day is not far distant when the nation will send abroad over $100,000,000 of American gold a year to pay for sugar which can and should be produced at home. It can be safely stated that by the adoption of a superior cultivation of our various farm crops, sugar for 50,000,000 people could be produced, and not a pound less cotton, tobacco, wheat, and other food stuffs, for home consumption and exportation raised.

Mr. Claus Spreckels and others have demonstrated that beets rich in saccharine can be raised in California, and it behooves our people, through the legislatures of the various states, to have the subject very thoroughly investigated by geologists, chemists, etc., and suitable localities designated not far removed from sources of abundant water supply and cheap fuel.

Our people are not called upon to grope in the dark as did the Europeans fifty years ago. They, after many years of patient investigation, have brought the cultivating, fertilizing and manufacturing to a high state of perfection, and all that is required here is the conviction that it can be, and the determination that it shall be done, and soon we will see factories erected in the various localities adapted to the growth of sugar beets.

One of the marked advantages in this country is the cheapness of the lands, the price being but one-tenth those in Europe, which cost from $140 to $500 per acre. There is an abundance of labor, cheap iron, limestone, building material and coal.

The colored people of the cotton belt will be found admirable operatives to cultivate and harvest the beet crop, as the men, women and children are accustomed to the use of the plow and hoe.

The early cultivation of the beet is very similar to that of the cotton plant. The pulling, topping and tailing of the beets is labor easily performed by the women and youths of both sexes.

One of the drawbacks to the rapid advancement of the beet sugar industry in California, now that the law precludes the possibility of obtaining the Chinese, is the want of an abundance of cheap labor. That may be obviated by deflecting the proposed emigration of the colored people to Mexico from Texas and other states to the Pacific slope, where the climate will be well suited to them.

The average cotton lands produce one-third of a bale of cotton per acre, worth to the planter less than $12, whereas an acre of beets will yield twelve tons, worth, say $50. Fertilizers can be had in abundance, as the cotton seed furnishes potash in the hull and nitrogen in the kernel (after the oil has been profitably extracted), and phosphates close at hand in the beds near Charleston, S. C.

All the data as to cost of plant, cultivation, fertilizers, etc., can readily be had and estimates made as to required capacity, etc. Europe has been enriched by fostering the industry, and there is no reason why such should not be the case in this country.

We are rapidly becoming the greatest sugar consumers known, and with our magnificent country and climate we should, with soils adapted to beets, cane and sorghum, become the greatest sugar producers in the world.—T. Mann Cage, in *Louisiana Planter.*

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WATTLE GROWING.

South Australia has done official forestry for fifteen years. The Adelaide *Observer* says there are 180,000 acres dedicated to forest purposes, which have been leased for fourteen and twenty-one years at rents ranging from 3d. to 2s. 8d. an acre. From the rents accruing £4,500 is annually obtained, while from the sales of timber, comprising sleepers, telegraph posts, fencing posts, rails, etc., about £6,000 is yearly added to the general revenue. Altogether this year's revenue will exceed £11,000. Against this is an expenditure of about £7,500, so that there will be a profit of £3,500. In addition it must be remembered that the department has planted a million trees this season, which, in fifteen years time or less, will be worth at least ten shillings apiece. Speaking approximately, the Forest Department has expended £60,000 and received £70,000 or a profit of £10,000. Of the 180,000 acres referred to, 40,000 represent natural forests, and 8,000 the area that has been planted, the remaining 132,000 representing reserves on which, the lessees are allowed to run their sheep and cattle.