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A DESCRIPTION
OF THE
IMPOUNDING RESERVOIR, CONDENS-
ING APPARATUS, AND COOLING
TOWER
FOR THE WATER SUPPLY AT THE
CHILDERS SUGAR FACTORY,
QUEENSLAND.

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The Colonial Sugar Refining Company's Childers Mill is situated in the Isis Scrub District, between the Burnett and Mary Rivers, in the southern part of Queensland. The soil in the scrub is of a rich, volcanic formation, red and chocolate in color, and of comparatively recent origin. The estimated area of the scrub is 20,000 acres. The rainfall on this area averages 48 in. per annum, and drains about equally into the Gregory and Isis Rivers, tributaries of the Burrum River, which discharges its waters into Hervey's Bay.

The site of the Childers Sugar Factory is nearly 360 feet above sea-level, and is distant about 6 miles from the Gregory and 7 miles from the Isis River, standing on a tributary of the latter called Apple Tree Creek. There is a considerable flow of water along the watercourse of this creek during the rainy season, but during the dry season it consists of a number of small waterholes, varying from 3ft. to 6ft. in depth. The various sites of the mill buildings, reservoir, &c., are shown on the general plan (Plate I.).

IMPOUNDING RESERVOIR.—The reservoir is formed by an earthen embankment across Apple Tree Creek, 400 ft. in length (Plate II.) and 29 ft. in maximum height, and is capable of storing 40,000,000 gallons of water. At present, however, the level of the waste watercourse is fixed so as to allow of the surplus water flowing through it, when there is impounded about 31,000,000 gallons. The embankment is constructed of earth excavated from the waste watercourse, and from the north bank of the creek. The top width is 10 ft., and is uniform throughout, the top of the embankment being 7 ft. above the highest water-level. The side slopes are 3 to 1 for the inner, and 2 to 1 for the outer, and are uniform throughout. Before commencing to build the embankment the site was carefully cleared of vegetable mould, trees and shrubs, and all sand and silt was removed from the area forming the foundations. A number of test-holes were sunk to a depth varying from 6 ft. to 8 ft., to determine the nature of the material forming the stratum immediately under the surface of the site of the embankment. This was found to consist of an average depth of 12 in. of clayey loam, 30 in. of good retentive clay, and the remainder of a mixture of clay and gravel. There is no puddle-wall in the embankment, as the material used in its construction was considered of good quality for the purpose. It was, however, found necessary to form a puddle-trench at the toe of the inside slope, where a bed of coarse gravel 30 ft. in width and $1\frac{1}{2}$ ft. in thickness was found at the bottom of the waterhole. A trench 10 ft. wide was cut to a depth of 3 ft. below the bottom of the waterhole, where a good bottom of clay mixed with gravel but free from water was found. This trench was followed up on both sides of the waterhole until the same kind of clay was exposed on both sides. In excavating this trench a large quantity of water was encountered, flowing in from the gravel-drift on the upper side. The water was pumped out of the trench, and selected material, containing about 50 % of clay, was thrown into it, and trodden upon by two teams of bullocks until

it was thoroughly consolidated, water being added to each layer of from 8 in. to 12 in. in thickness. This process was continued until the selected material was carried up and thoroughly incorporated with that forming the inner toe of the embankment, so as to have a water-tight junction with the earth-work of the dam. After the material deposited in the trench and waterhole had been thoroughly consolidated, the work of building the embankment was then proceeded with. The material as it was received from the drays was carefully broken up, levelled in 9 in. layers, and moistened with water, to ensure thorough bonding. Two teams of bullocks, each working 4-hour shifts, were used to consolidate it, with very satisfactory results, which were evident from the slight impression that was made by the wheels of the loaded drays while passing over the surface when building operations were in progress, and subsequently, from there being no perceptible settlement in the embankment when this was completed. The inner slope of the embankment is protected by a layer of hand-packed stone, 6 in. deep, with a special course of headers, 18 in. deep, bedded into the embankment every 6 ft. up the face of the slope. The face of the outer slope and the top of the embankment is covered with good soil and planted with Buffalo grass.

A scour pipe was laid down as shown on Plate IV. The valve of this is placed in a concrete well, and is protected by a perforated cast iron plate, with an iron scraper fitted on top and a stirrer underneath, for the purpose of straining and stirring up any material which may settle round the valve. The scraper, the stirrer, and the valve are actuated from a platform built in the reservoir. The scour pipe is bedded in a trench packed with selected material, and fitted with gills throughout, to prevent leakage of water along the outside of the pipe. No special provision was made during the construction of the embankment for the passage of storm-waters, as it was considered that the scour pipe was of ample capacity to run off all the water likely to find its way into the reservoir during the months that its construction was being proceeded with.

WASTE WATER COURSE.—The waste water course (Plate I.) is 450 feet in length, with a mean width of 40 feet. The ground forming this course consists of clay of varying quality, the bed of the channel being very hard in character. It was not considered necessary to pave or protect the surface of the bottoms in any way, with the exception of the discharge end, which is protected by hand-packed stones. The sides of the waste water way have a slope of 3 to 1, and are pitched with hand-packed stones at the entrance and exit ends. It is estimated that the maximum flood discharge—1,700,000 gallons per hour—would rise to a height of 3ft. 6in. in the waste water course. This discharge is equivalent to $\frac{1}{2}$ in. of rain per hour on the catchment area of 625 acres, most of which is land under cultivation. The figures in the appendix show that the greatest amount of run-off water which found its way into the dam when the ground was saturated was 25 % of the registered rainfall, and for the month of January, 1895 (which is the only month this year that there has been the usual wet season's rainfall), the amount registered was 20.5 inches, $10\frac{1}{2}$ % of which found its way into the dam.

The work of building the embankment was begun on 1st August, 1894, and finished early in January, 1895. During the last-mentioned month, as above indicated, 20.5 inches of rain fell on the catchment area, and on the 29th of the month, the level of the reservoir was just at the bottom of the waste water way; but there was no flow of water in it, and up to the present date, the rainfall has not been sufficient to cause a flow in the waste water way.

The quantity of water impounded in the reservoir—31,000,000 gallons—is estimated to be sufficient for a 30-weeks' supply, on the assumption that the factory is working up to its full capacity of 3000 tons of cane per week, and that no inflow of water takes place during that time.

PUMPING PLANT.—The pumping engine at the reservoir is of the duplex type steam cylinder 10 in. diar. pump $6\frac{1}{2}$ in. diar. x 12 in. stroke, capable of delivering 10,000 galls. of water per hour to a height of 132 feet. The distance from where the pump is placed to the mill is 2000 feet, and the former is supplied with steam from the factory boilers through a $2\frac{1}{2}$ in. W.I. pipe fitted with 6 expansion joints (Plate III.), each one being capable of permitting a movement of 5 in. The total expansion of this pipe when in working condition is about 30 in. The steam supply and water discharge pipes are carried partly in a trench which forms the drain for the waste water from the mill and partly on trestle work, as shown on Plate III. The steam pipe is securely anchored at a point half-way between each expansion joint; this causes the pipe to expand equally on each side of the anchor, and therefore each expansion joint has the same amount of movement, so that the pipe cannot creep down-hill towards the pump. The steam supply to this pump is controlled by a throttle valve and a float in the tank into which the pump discharges. This tank is of 7000-galls. capacity, and the float is so adjusted that it shuts the steam off the pump when the level of the water is about 10 in. from the top and opens the throttle valve full when the level of the water has fallen to 3 feet from the top.

This pump has no special attendant, but is visited about every three hours by one of the Engineer's assistants. It is fitted with self-acting lubricators for continuous oiling. There is a steam reservoir with a capacity of nine times that of one of the cylinders fitted on the end of the steam pipe, to equalise the speed of flow of the steam through the long pipe. By this means the maximum velocity of the steam does not exceed 1500 feet per minute, observations made by the writer revealing the fact that the fall of pressure between the boilers and the engine was inconsiderable, and the lagging of the steam pipe at that time was not finished. A Royle Syphonia steam trap is fitted to the bottom of the steam reservoir, to drain off

the water condensed in the pipe. The suction pipe of the pump is 260 feet in length, and is carried under the stage leading to the scour pipe valve handle. A suitable strainer is fitted on to it, to keep floating debris from getting into the pump.

From the 7000-gallon tank (Plate V.) the water supply for the mill and other purposes is distributed as follows:

3000 galls. per hour to make up for the water lost in the vapour which passes away in cooling the condensing water as it falls through the shelves of the cooling tower.

650 galls. per hour on account of spraying, saturating the air, etc.

600 galls. per hour used as supplementary feed water for mill boilers,

250 galls. per hour for locomotives.

350 „ „ for domestic uses and stock.

150 „ „ for contingencies.

The factory runs day and night, and a total of 150 hours per week has to be reckoned on, the weekly consumption of water being 750,000 galls., or for 30 weeks 22,500,000 galls. This makes the difference between the total amount stored and that consumed 8,500,000 galls., of which 4,500,000 galls. are allowed for loss through evaporation, for six months of the year, 1,500,000 galls. for seepage, and 1,500,000 are calculated on being left in the reservoir at the end of the season for stock and other uses.

Special observations made by the writer to determine the actual evaporation since the completion of the reservoir show that this amounts to about six feet per annum, which is equal to an evaporation of 8,000,000 galls. from the calculated average surface area of the water.

SURFACE CONDENSER.—The surface condenser (Plate VI.) is of the ordinary marine type, containing 2765 tubes $\frac{3}{4}$ in. ext. diam. x 9ft. 3in. long, arranged in five nests, each containing

558 tubes, with a total cooling surface of 5000 square feet. The condensing water passes in at the bottom nest and comes out at the top. There is nothing special in the design of the condenser, with the exception that particular care was taken to allow the vapour from the evaporating apparatus to get freely among the tubes, and channels have been formed by leaving out tubes, so that the vapour may get into the lower tubes more readily. The quantity of vapour condensed per hour is about 30,000 lbs. or equal to 3,000 galls. of condensed water per hour ; and as the installation has been designed to operate on this quantity during the part of the season when the condensing or cooling water has a temperature of from 90° to 95° Fah., and the water from the condensed vapour a temperature of about 115° Fah., it can readily be seen that the weight of condensing or cooling water is nearly 50 times that of the vapour condensed, and that the amount of water in circulation through the condenser tubes and over the cooling tower, is about 150,000 galls. per hour.

Plate V. shows the position of the various tanks connected with the water supply ; tank (Fig. 1) of 7,000 gallons capacity receives the water from pump at the dam ; tank (Fig. 2) of 20,000 gallons capacity is the one from which the surface condenser is supplied ; tank (Fig. 3) of 4,800 gallons capacity receives the cooling water after passing through the condenser. This latter tank has a float fitted which regulates the speed of the duplex 22½ in. x 20 in. x 24 in, circulating pump (Fig. 4), and is arranged to keep the level of the water about 3 feet from the top. The pump, when doing full duty, raises 150,000 gallons of water per hour to the top of the cooling tower.

COOLING TOWERS.—The site of the cooling towers is indicated on plate 1, and is 240 feet on the north-east side of the mill, its height from mill floor level being 80 feet. The circulating water pump raises the water to the top, where it is distributed, half of it going to each side. The top of each section

is close boarded with lin. boards, and forms a tank 20ft. x 20ft. x 15in.; holes $\frac{3}{4}$ in. diameter are bored at 3in. centres through the bottom, to distribute the water as uniformly as possible over the entire surface. The height of the cooling tower from the tank into which the water falls is 40ft., and is divided into ten shelves about 3ft. 6in. apart, each of the shelves being covered with a mattress of wattle-tree branches about 7in. deep. The branches are laid uniformly over the entire surface, and fastened by galvanized iron wire to keep them in position.

The shutters or baffles (Plate IV.) have been fitted to prevent water from being blown on windy days clear of the 55,000 gallon tank (Fig. 5), and in order to reduce as much as possible the loss by spraying. The bottom of the W.I. tank at the cooling tower is 12in. higher than the top of the tank from which the condenser is supplied, and the head required to cause 150,000 gallons an hour to flow from tank to tank through an 18in. pipe is about 2 feet.

When the factory commences work, the large pump is started first, and the float in tank (Fig. 3) regulates the speed, so that it will just pump the quantity of water passing through the condenser. The water in the tanks (Fig. 2 and 3) is by this means put into circulation, and as the loss by evaporation in cooling the water after passing through the condenser lowers the level in tank (Fig. 2), the regulating float sinks and opens the throttle valve (Fig. 6), and lets in the make-up water from tank (Fig. 1). When tank (Fig. 1) in turn has its water-level lowered more than 10in. from the top, the regulating float opens a throttle valve and admits steam into the pipe leading to the pump at the reservoir.

The rate of work and the quantity of water in circulation are controlled by the attendant at the vacuum pan station, who increases or reduces the quantity by means of the valve (Plate V.) so that a high vacuum is maintained in the vacuum pans, &c.

The importance of cooling the condensing water and using it over and over again is manifest when it is seen that the quantity of condensing water required to keep the factory supplied if used in the ordinary way would empty the reservoir in about ten days, and it appears to the writer to be the only practicable way to keep a factory using such large quantities of water in its operations going where the water supply is limited.

There is not, so far as the writer knows, any experimental data on the rate at which water may be cooled by causing it to fall in a fine spray through a number of stages; and although there are many cooling towers in use in Queensland, there is no reliable information as to the quantity of water that may be cooled per square foot of surface. The cooling towers at Childers have been designed to permit the whole of the vapour formed by the cooling of the condensing water to be carried away by a gentle breeze not exceeding one or two miles per hour, so that it may readily part with its heat. The layers of wattle-tree branches are very effective in breaking up the water into a fine spray, and thus facilitate the act of cooling.

The factory has been running for some time, and the water supply installation has been working satisfactorily, with the exception of the discharge pipe from the pump to the tower; the joints of this—which are spigot and faucet filled with lead in the usual way—have given considerable trouble through leaking, this being caused by the expansion and contraction of the pipe, due to the variation in temperature which may at times reach 130 degrees Fah. It may be necessary to remove the lead from the joints and substitute rust cement, and also to make provision for the free movement of the pipe in the trench leading from the pump to the tower.

As the object of this paper is to invite discussion on the subject of water supply for industrial purposes where the natural supply is limited, I will conclude by saying that the designs of this factory, which is capable of crushing from

90,000 to 100,000 tons of sugar cane in from 25 to 26 weeks, were made in the drawing office of the Colonial Sugar Refining Co., Ltd., under [the supervision of Mr. W. H. German, a member of the Association. The civil engineering part of the work was carried out by Mr. T. Stephens, B.E. of Sydney University, and the mechanical engineering department was in charge of Mr. McGechan. The author would also take the opportunity of thanking the General Manager of the Company, Mr. E. W. Knox, for his assistance and permission to bring this subject before the members of the Association.