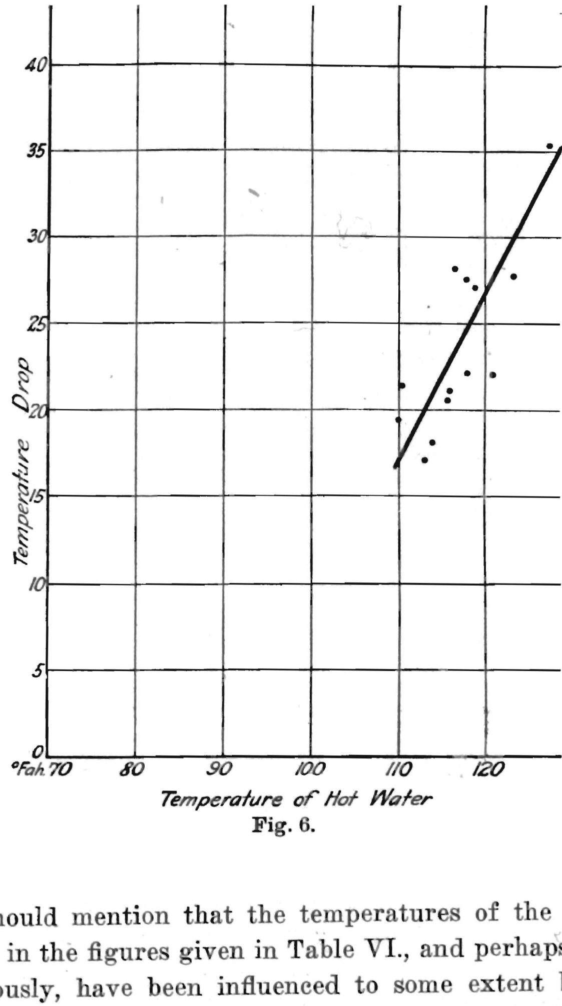

Fig. 6.

I should mention that the temperatures of the cooled water in the figures given in Table VI., and perhaps those previously, have been influenced to some extent by the addition of small quantities of cooler water to freshen up the water in circulation. There is no record of the quantity added. The reduction in temperature due to this cause is probably within one or two degrees.

There was no addition of cooler water during the trials given in Table VII. ahead, and for those in Table IX. the quantity added was practically negligible.

Spray Cooling.

As previously stated, I was unable to arrive at, by calculation, the amount of cooling which might be expected, and not having comparative data for similar atmospheric conditions to work on, a spray nozzle was made. The few observations made to determine the amount of cooling effected and the capacity of the nozzle gave promising results. In 1916 an experiment on a larger scale was carried out, approximately ⅓rd of the water going to the sprays and ⅔rds to the towers. The results from this plant, which will be designated No. 1, and another small system, No. 2, at one of the other Queensland mills of the Company, were so satisfactory that it was decided to entirely replace the towers by a spray cooling system.

Fig. VII. shows the type of spray nozzle used.

Sectional View of 2½ "Nozzle."

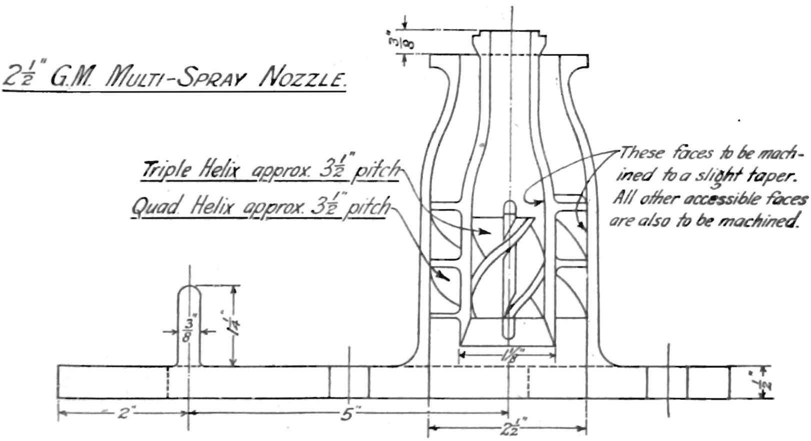

Fig. 7

Spray Nozzle.

The nozzle is similar in design to the Koerting Low Pressure Multiple Spray Nozzle. As will be seen, it consists of two concentric nozzles, both provided with spirals, the inner one separate and the outer one cast on the inner nozzle. The inner nozzle and separate spiral are held stationary by jambing into the taper, so that there are no moving parts to wear out. The extended base enables the nozzle to be moved along on its seat. for cleaning, and also does away with the necessity of fitting isolating valves. The nozzle is made of gun-metal, and all water ways are machined smooth to reduce friction losses.

The water, in passing through the spirals, is given a rapid rotary motion, and is ejected in the form of two distinct conical sprays, the drops from which, when falling, collide and break themselves into smaller drops, and by suitably spacing the nozzles additional collisions are obtained.

The smaller the drops the greater the amount of cooling effected; the greater the pressure the larger the spray and the smaller the drops. On the other hand, the larger the spray and the smaller the drops, the greater the drift loss.

Pressure and Drift.

A pressure of 5 to 6 lbs. at the base of the nozzle appears to be the usual practice with drift and evaporation losses combined below 2 per cent. In this instance drift and evaporation losses are of no account; with barometric condensers the quantity of water in circulation increases.

I cannot give what the pressures at the nozzles were, but those in the main distributing pipes entering the pond varied from 8 to 16 lbs., the sprays in still air covering a circle up to 35ft. in diameter.

Strainers.

Although the water ways through the nozzle are large, clogging is always likely to occur. Lopsided and coarse sprays mean less cooling. Suitable strainers, with facilities for cleaning, should be provided at the pump suctions.

Arrangement of Sprays.

The No. 1 plant consisted of 9-3in. nozzles, of the type shown in Fig. VII., arranged in three groups of three, the groups being spaced at 20 feet centres, and the nozzles in each group at 10 feet. The central nozzle of each group was 3 feet higher than the two outer ones, the idea being that not only would there be a greater number of collisions of the drops and an appreciably larger period of some of the drops in the air, but an improved air circulation. From subsequent observations it is doubtful whether there is anything to be gained by it. Temperatures were taken of the water in the pond in various places, and of the sprays from different nozzles with practically identical results, notwithstanding the fact that the observer was, by his sense of feeling, able to select temperature difference. The cooler places were always to windward, and were, no doubt, the effect of greater evaporation from his body.

The No. 2 plant consisted of 15-2½in. nozzles arranged in five groups of three each, the groups being spaced 30 ft. centres and the nozzle in each group at 15 feet, with provision for additions between. One nozzle in the last group was not in use. Otherwise the two layouts were the same. Figure VIII. shows a photograph of the No. 2 plant in operation.

Results from Towers and Sprays.

To determine the respective efficiencies of the two systems, viz., Towers and Sprays, temperature observations of water and air, and observations of weather conditions, were made at 3 a.m., 9 a.m., 3 p.m. and 9 p.m. each day. I do not propose to give the observations in

Fig. 8.

detail, but only the final averages, embracing all conditions met with. These are given in Table VII. No observations are omitted from the averages.

TABLE VII.

	Towers.	Sprays No. 1 Plant.	Sprays No. 2 Plant.
Approximate gallons per hour... ...	9000	45000	48000
Inlet temperature of water °F	123	123	112
Outlet temperature of water ° F ...	102	103	88
Temperature drop in water ° F ..	21	19·5	23·6
Temperature of air ° F	76	76	78
Relative Humidity %	70	70	74
Temp. diff. betw. cooled water & air °F.	26	27	10
Number of observations ...	40	38	72
Pressure of water in main (lbs.)	—	$8\frac{3}{4}$	14

The sprays, No. 1 plant, which were on the same pump circuit as the towers, were frequently clogging with small pieces of wood from the tower grids. With the sprays free, the temperature drop was as a rule 2° greater than at the towers.

The better results from the sprays, No. 2 plant, are considered to be due to the finer subdivision of the water obtained by working at a higher pressure. The smaller nozzle appeared to give a more uniform spray.

Effect of Humidity.

In Table VIII. the observations for the two spray systems have been sorted out to show the effect of humidity. The amount of cooling is practically the same, irrespective of the humidity. It will be noticed that the higher the humidities the cooler the air; the high humidities occur at 3 a.m., and are no doubt due mainly to the cooling of the air. The assumption is that the decrease in the rate of cooling due to increased humidity is counterbalanced by the increase in the rate of cooling due to radiation and for convection, or, the air supply is so vast that the effect of humidity is hardly felt.

TABLE VIII.

	No. 1 Plant.			No. 2 Plant.			
Humidity	40 to 65.	65 to 80.	80 to 95.	48 to 65	65 to 80	80 to 95.	95 to 100
Inlet temperature ° F...	123·6	121·9	122·7	111·6	112	113	111·2
Outlet temperature ° F	104·4	102·6	102·9	87·5	90	88	86·7
Temperature drop ° F...	19·2	19·3	19·8	24·1	22	25	24·5
Temperature of Air ° F	82·1	75·4	70·2	85·0	83·	77·1	70·0
Air humidity %... ...	59	73	85	56	77	89	95
Tem. dif. cooled w't'r. & air	22·3	27·2	32·7	2·5	7	11	16·7
Number of observations	13	7	18	11	25	13	23

In the No. 2 plant only about half the total condensing water was artificially cooled; it was thus possible, by manipulating the supply, to send water to the sprays at temperatures both considerably below and above the usual working range. This was done with a view to establishing a curve to show what amount of cooling might be expected for a wide temperature range of the hot water under the usual atmospheric conditions.

The results obtained for these outside temperatures are not included in the average given in Table VII., but all the observations have been made use of in establishing the diagram given in Fig. IX.

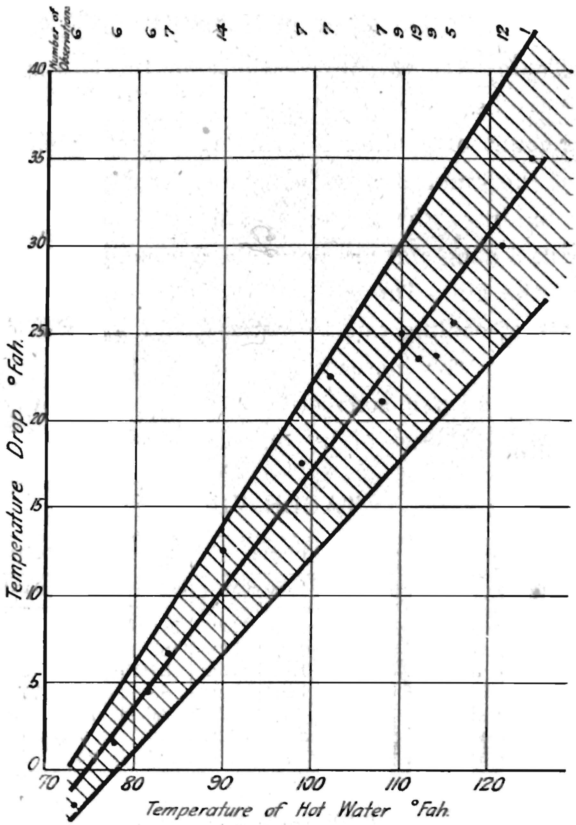

Fig. 9

The temperature drops for any given temperature of hot water falls within the hatched area, from which it is clear that a greater variation in the amount of cooling to be expected for higher temperatures of the hot water. I have indicated by dots the average of the temperature drop for all cases in which there were five observations or over for a given temperature of hot water, and through these dots a mean curve has been drawn.

This curve has some practical value; it enables the question whether a second spraying of all or part of the water is a payable proposition. For instance, with hot water at 110° Fahr. the average temperature drop for one spraying is, by the curve, approximately 24° Fahr., the temperature of the cooled water being then 86° Fahr. A second spraying of the whole of the water would reduce this temperature to 79° Fahr. For a 27in. vacuum this further reduction in the temperature of condensing water would, by the curve given in Fig. IV., reduce the quantity required by 22 per cent., or, if it were desirable to maintain a fixed vacuum of 27in. under all atmospheric conditions, a second spraying of the average quantity of water during adverse conditions would be necessary.

Fig. X. shows the final lay out of the spray cooling plant replacing the towers, and Figs. XI. and XII. two views of the plant in operation.

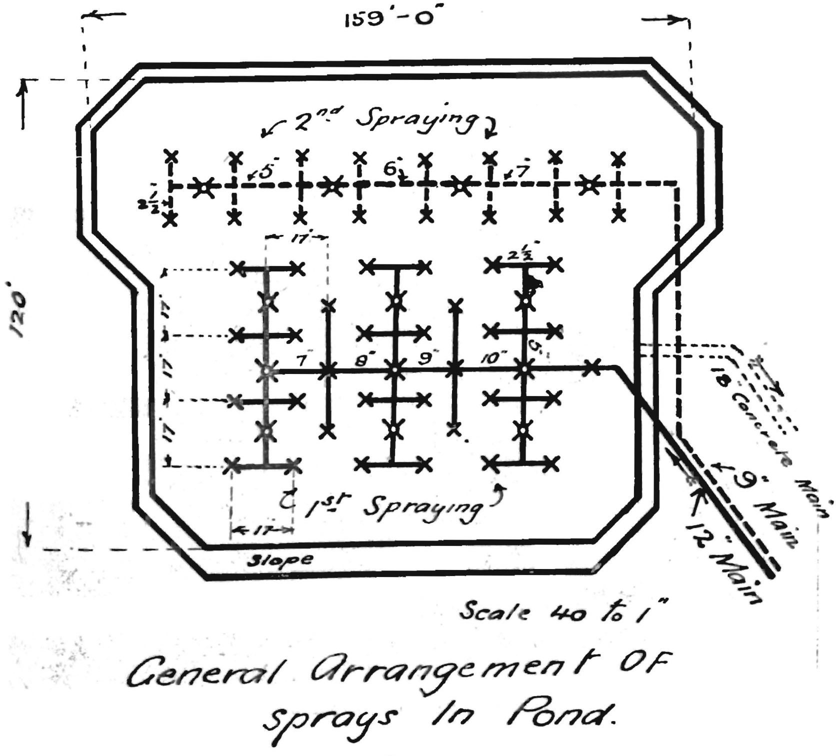

Fig. 10.

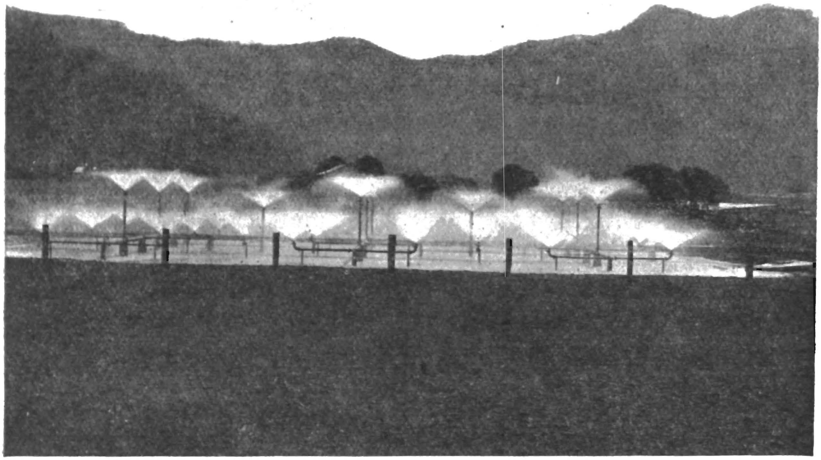

Fig. 11.

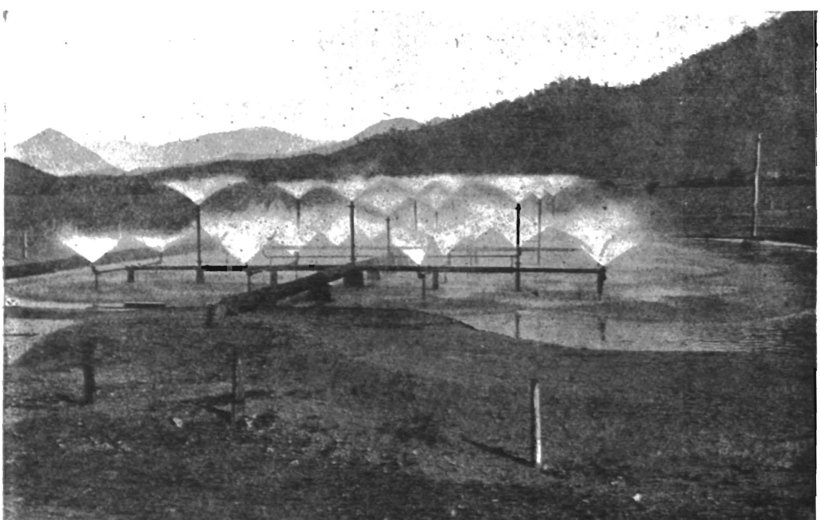

Fig 12.

Table IX. gives the average of the results obtained, first, with a pressure of 10½ lbs. in the distributing main, and, second, with a pressure of 13 lbs.

TABLE IX.

	Pressure in distributing main	
	10½lbs.	13lbs.
Approximate gallons per hour	125000	125000
Inlet temperature of water °F	113·6	104·0
Outlet temperature of water ° F ..	92·5	83·3
Temperature drop	21·1	20·7

As in Table VI., the figures for the temperatures drop, and if read alone, are misleading; actually the efficiency of the plant has been considerably improved by increasing the delivery pressure, i.e., the size of the sprays. This will be more clearly seen in Fig. XIII., in which the temperature drop has been plotted against the temperatures of the hot water for the individual readings. The curve from Fig. IX. is included, and shows close agreement.

Double spraying all or part of the water or single spraying at higher pressures will increase the amount of cooling; the former will probably be found to give smaller drift losses, but where drift losses are of no importance the latter should prove the more economical. For the plant is question there was no more power available to increase the pressure.

No scientific accuracy is claimed for the figures given. In only a few cases were simultaneous observations made; in the main the figures were recorded by the mill staff, who had other more important duties to perform. I have for this reason given averages in preference to individual figures, but, on account of the large number of observations made, they should represent more or less accurately the true facts. All the matter given has been taken from the Company's records. I should state here that my personal connection with the plant described only dates from 1910.

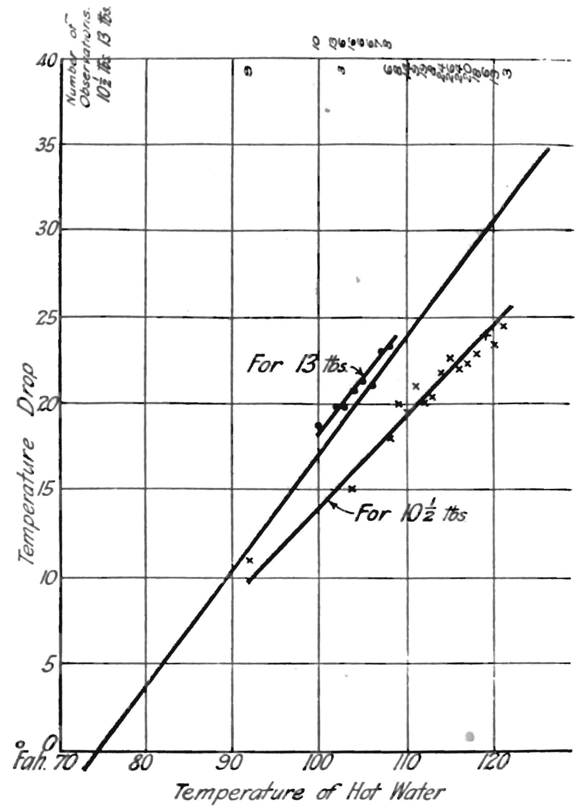

Fig. 13

In conclusion, I take this opportunity of thanking the General Manager of the Company for his permission to use the Company's records and to place before this Association the experience gained. I also desire to thank those members of the Company's staff with whom I have been associated with in this investigation for the assist-
been associated in this investigation for the assistance given me.