# DISCUSSION.

**Mr. Howarth** said:—The subject which had been so clearly presented was one that was calculated to enlist the attention and consideration of all members of this Association who were in any way interested in the problem of water conservation for the irrigation of land, as a constant supply for manufacturing purposes, or for domestic consumption, and the author had expressly stated "that the object of his paper was to invite discussion on the subject of water supply for industrial purposes, where the natural supply was limited."

In the recognition of these important reasons for a discussion, he (the speaker) ventured to ask for certain information that did not appear in the paper; and although the queries might seem to be inquisitive, it was certain that their satisfactory answer would be of great value to all who were engaged in similar works for the supply and storage of water. The first query related to cost of construction of the impounding reservoir, installation of pumping plant, service of water per 1000 gallons, and estimated cost of future upkeep. Before proceeding with the construction of the extensive work described in the paper, it is presumed that comparative cost estimates would show that the system adopted was superior to any other known method of water supply for the purpose. He could further mention artesian bores, and ordinary drive wells, or a direct service from the Gregory or Isis Rivers, which were said to be six or seven miles away from the mill. It would be pleasing to know whether any of these services could be entertained. A very few relative cost figures would be useful as a further addition to the value of the author's paper, and he trusted that Mr. German would see no objection to supplying same. His second query related to a doubt whether the repeated use of the water did not ultimately result in the production of a soupy sort of liquid of questionable fragrance and of such a pungency that its presence was objectionably perceptible. One of the first requisites in the preparation of all factory-food products was sanitation of the atmosphere Probably Mr. German could satisfactorily explain the defence provisions that had been made for the purpose of nullifying those contingencies which he had just mentioned. He proposed to leave all criticism of the pumping and condensing plant to those members whose daily experience of kindred machinery enabled them to speak with certainty and authority.

With reference to the effective working of the cooling towers, he would like to ask Mr. German as to whether any experiments had been made to ascertain if the effluent water was much lower in temperature than the surrounding air, and with what result? The reason for this question was a consequence of an interesting and illustrated article that he recently read in the *Revue Industrielle*, and in which was fully described a new kind of faggot refrigerator, possessing the interesting and peculiar faculty of cooling water to a considerably lower temperature than that of the surrounding air. Though, of course, the phenomena of producing a lower degree of temperature in water than that of the atmosphere was familiar to all of us who have seen or used a canvas water-bag, or applied a wet wrapper to a water-pipe or bottle, it would be probably of some interest to the members of the Association, if he were permitted to describe the cooling apparatus. This apparatus, which was devised and patented by Mr. Rohleder, is not much unlike the ordinary faggot refrigerators constructed of wood, while in reality it differs greatly from them. The principle upon which its operation is based is naturally the same; that is, the evaporation of the liquid that is required to produce the necessary cold; but the inventor has made an ingenious extension of this principle by submitting the same water to a succession of evaporations. It is claimed that this cycle of operations produces a much lower temperature of the cooled water than that of the surrounding air.

The apparatus is constructed wholly of iron, so that its stability leaves nothing to be desired. Its length is determined by the quantity of water to be cooled. Accordingly, as the temperature of the latter is above or below 30° centigrade, it is constructed with two or more superimposed sections, each forming a refrigeratory of 6, 7, 8 or 9 rows of faggots. The section with the greatest number of faggots is placed on the top, the next lowest section containing one less row of faggots, and so on to the bottom. This arrangement of sections provides the largest area of cooling surface of faggots for that portion of the stream which is of the highest temperature and greatest volume, the faggots in the lower sections being less in quantity, so that the less area may coincide with the reduced volume of cooling water, consequent upon the loss by evaporation during transition from the highest to the lowest row of faggots.

Above each section a trough is placed for the reception of the water, the bottom of which is perforated with feeder holes for each vertical row of faggots. A special arrangement provides for the uniform flow of water for the whole length of the trough. The water is raised by a pump to the upper trough, and from thence flows to each successive section in a similar way as that described by Mr. Kidd. The apparatus has neither shutters or louvres of any kind, and it is claimed that the more the wind blows, the better will it work. The apparatus required but very little attention or supervision, and as for maintenance—well, that consisted simply in replacing the faggots of heather or bunches of small twigs, whenever they decayed or were damaged.

MR. L. C. AULDJO said he would like to know what was the cost of fuel at the Childers Mill? He knew, of course, that crushed cane or megass formed the greater portion of the fuel. The reason he asked what cost of fuel was, was on account of seeing two ordinary Duplex or Worthington type pumps. These pumps were simple, no doubt, but they used very much more steam than even the single type of pump, such as the Blake or Tangye, and even then he should have preferred a compound pump. He understood that the large pump at the factory was connected to the surface condenser, though the paper did not say so; but why not use an ejector condenser, with the pump at the reservoir? He felt convinced that, if the reservoir pump had been a Blake compound, with an ejector condenser, a 2in. steam supply pipe would have been ample, and the difference in price between 2000 feet of 2½in. and 2in. pipe would have paid for the extra first cost of the pump, and the saving in fuel would have been not less than 25 %, and possibly more like 50 %, taking into consideration the steam-consuming capabilities of the duplex type pump. And as the load was constant, he did not think the Blake pump and ejector condenser would require any more looking after than the duplex pump. In regard to the Cooling Tower, he questioned whether the natural draft method adopted was either the best or cheapest for this class of work. During the last few years mechanical draft for water-cooling had come very much into use, more particularly in connection with brewing and refrigeration, both in Europe and America. He was sure most of the members would be surprised to learn that it was possible to reduce the temperature of the water 25° below that of the atmosphere, with a well-designed mechanical draft-cooling plant.

An explanation of this fact was given in *Ice and Refrigeration* for March of this year. The efficiency of the plant depends—1st, on the quantity of air brought in contact with the water; 2nd, on the ability to spread the water into the thinnest possible films; and 3rd, on retarding the motion of the water as much as possible. The amount of water lost by evaporation and leakage ranged from 5 % to 10 % of the amount circulated. He had erected several of these water-cooling plants in connection with refrigerating work, when the supply was short or cost too much. The plan adopted by him at the Melbourne Chilled Butter and Produce Co.'s works, Melbourne, was equal to the melting of six tons of ice per 24 hours. With cooling water at 75°, this plant would require 1500 gallons of cooling water per hour. This at 1/- per thousand gallons was equal to 36/- per 24 hours for cooling water. This plant was erected close to Collins-street, and the place was surrounded on all sides by high buildings, so that the usual water-tower with natural draft was out of the question. The cooler had proved very successful. The casing was made of plain galvanised iron, and was 2ft. 6in. square by 5 ft. deep. In the centre of this casing, and about 3 ft. high, was a framing made up of 3in by $\frac{1}{4}$in. rough sawn timber battens standing on edge, spaced $\frac{1}{2}$in. apart, and crossed alternately at right angles, the whole being bolted together. The warm water from the condenser entered by a funnel-shaped opening on top, and was spread over the surface of the battens by a four-branch Whitelaw's wheel, on the same principle as an ordinary lawn sprinkler. The water gradually trickled down over the battens, and eventually found its way out through the opening at the bottom, when it was at once picked up by an ordinary belt-driven rotary pump and again lifted up to the condenser. A Sturtevant blown at 2600 revolutions per minute delivered 600 cubic feet of air through a square opening on one side at the bottom, and this air, after cooling the water by evaporation as it passed it in going through the battens, was finally discharged out at the top by the pipe on top. One very warm day he tested the air and water with the following results:—The shade temperature was 90°, and this was the temperature of the air entering the cooler. The water from the condenser was 100°, and when it left the cooler was reduced to 90°. The air leaving the cooler had risen to 100°; so that the air rose 10 % and the water fell 10 % in passing through this cooler, showing an exact exchange of temperature.

He should state that he obtained the main features of this design of cooler from the one built for the "Capitaine" Oil Engine, which some of the members were acquainted with.

MR. NORMAN SELFE said the members were indebted to the author for bringing this interesting subject before them, because, in connection with the industry to which Mr. Auldjo referred, the conservation of water was of very great importance. There were one or two things in the paper that were not exactly clearly put, and the speaker was inclined to think that possibly the same results might have been achieved in a somewhat cheaper manner, but he felt certain that there was nobody in a position to dogmatise on this matter, the science of cooling being in an experimental stage, and every example like the present is a direct gain adding to the general experience. The author was somewhat wrong in stating there was no data obtainable, because the laws of evaporation were clearly understood, and were so direct and so certain that they never failed. There were one or two very important points to be borne in mind in starting to set up cooling arrangements of this kind, the whole thing depending upon how close the water could be brought into connection with the air, and the condition of this air when it was brought into contact with the air, because a pound of air at 32° might be saturated with moisture, whereas brought down to 40° or 50°, it would be absolutely dry as far as our sense goes, and would then take up a great deal of water, and evaporation would be possible. If it was cooled down to atmospheric temperature. 150,000 gallons of water lifted 80 feet represented 66 horse power. The horse power here must be at least 100, and he felt certain that if 50 horse power was expended in raising the water, and the other 50 expended in promoting a powerful blast of air, the evaporation would be three or fourfold what it was; especially so by getting it into a state of extreme sub-division. If the temperature of the air be raised, of course, its power of taking up water would be increased. He might mention he had seen the water go on the surface of a condenser, and come off at the bottom 4° colder than it went on at the top, but the water was very warm, and was taken through pipes, and there was a dry wind blowing on it, and the evaporation so caused abstracted the heat. It seemed to him that so many mattresses of fibre were comparatively unnecessary, also that the screens to work the wind were put up the wrong way, and that they sent the wind upwards to meet the descending water, and he felt perfectly certain that the evaporative power could be nearly doubled if the wind striking against the louvres were turned upwards. The holes also through which the water came in appeared to him to be too large. The whole subject was fraught with so much interest in the minds of them all, that more information would be very acceptable, as the interior machinery was wanted and water necessary. The great height of the tower seemed to him a serious matter, and it would be worth a trial to enclose the structure on the windward side.

MR. J. S. FITZMAURICE asked if the water ran to waste in the event of the pump breaking down.

MR. CRUICKSHANK said he was sorry the author was not present to hear the discussion. The previous speakers had certainly opened up a subject upon which, so far as he could see, there was very little to discuss, and, as Mr. Selfe observed, it is one of the most important in this colony where the science was comparatively in its infancy. In reading the paper, he thought that, perhaps, everybody would be of the same opinion, and that there would be very little criticism; and, therefore, he had put together a few remarks in connection with the author's scheme which would be more particularly appreciated by the younger members. The paper, although principally of a descriptive character, was both interesting and instructive. It was also very suggestive of how a thorough knowledge of mechanical principles could be practically applied to overcome our climatic difficulties. What the author had successfully demonstrated was, that condensing engines could be worked with the same cooling water over and over again, without materially lessening the engine's efficiency, and he showed very clearly how this was done. Now, what could be done in one place could be accomplished in another, and numerous cases must occur to many present, where, by the adoption of this principle, the power developed would be nearly doubled, and yet use no more steam than under the present wasteful system. Taking the paper as a whole, there was much to commend, but very little to criticise, and after reading it the thought suggested itself to him that, if time permitted, a few practical remarks on some of the mechanical principles involved might not be out of place, as we had several of our young engineers present. He had therefore made a few rough notes, which, with permission, he presented on Evaporation, Condensation, Exhaustion and Expansion.

## IMPOUNDING RESERVOIRS.

Actual dimensions were not very clear. In the paper, the length was given as 400 feet and 29 feet maximum height, the breadth was not mentioned, but the statement that "the top width is 10 feet and is uniform throughout, the top of the embankment being seven feet above the highest water-level," enables us to assume that the depth when full up to the level of waste watercourse would be 22 feet.

Now, as the reservoir had a capacity of 31,000,000 gallons

$$= \frac{31,000,000}{6\cdot2} = 5,000,000 \text{ cubit feet,}$$

the breadth must (like Paddy's plank) be much broader than it is long; but he presumed the 400 feet given was in the direction of the creek's length; having the length, depth and capacity, the breadth would be 568 feet. Thus:

$$400 + 22 = 8800 \text{ sq. feet and } \frac{31,000,000}{6\cdot2} = 5,000,000 \text{ cubic ft.}$$

$$\text{Therefore } \frac{5,000,000}{8800} = 568 \text{ feet broad—}$$

Proof: $568 \times 400 \times 22 \triangleq 5,000,000$ cubic feet,

$$\text{And } \frac{5,000,000}{6\cdot2} = 31,000,000 \text{ gallons} = 138,437 \text{ tons.}$$

## EVAPORATION.

The figures given by the author, relating to the amount of water lost by evaporation, were suggestive and interesting, and in referring to them, it would be found that the consumption for 30 weeks was 22½ million gallons, and that the difference between the quantity stored and the quantity consumed was 8½ million gallons, the loss being accounted for in the paper; but the most pertinent remark relating to this particular and important part of the subject was where the author states that "special observations to determine the actual loss from evaporation since the completion of the reservoir show that this loss amounts to about 6 feet per annum, which was equal to an evaporation of 8,000,000 gallons from the calculated average surface of the water."

This amounts to over 25 per cent. of reservoir's capacity, and it occurred to him that, although in this case the area of water level was exceptionally large, still in many places in Australia where reservoirs had been constructed it would be desirable and justifiable to roof them over even in a rough-and-ready way, which would prevent to a very great extent this enormous loss from evaporation, incidental to our climate.

In many places they had all the necessary materials handy —timber, bark, and handy bushmen. At all events, it might be worth considering, and the moderate cost of such structures would probably turn out a good investment.

In the present instance, the "area" is possibly too large to justify the expense; but if it could be done, it would result in a double advantage, as I shall endeavour to show.

## CONDENSATION.

Taking the figures in the paper relating to condensation, it would be seen that the condensation part of the plant was designed, or rather had to be designed, and allowance made for cooling water where the temperature was 95° F., the hot well temperature being 115° F.

The resultant of such conditions as the author points out, was that the weight of water required to condense the steam was as 50 to 1—viz., every pound weight of steam requires 50 pound weight of water to condense it and keep it at the practically constant temperature of 115°. Perhaps it might be desirable to explain this in detail. Assume that the steam was exhausted at 5lbs. absolute, (10lbs. below atmospheric pressure) the temperature of the steam would be about 160°, and as the total heat in steam of one lb. absolute, was 1114° we had

$$\frac{1114 + 0{\cdot}3 + 160 - 115}{115 - 95} = 52\text{lbs. of water to every lb. steam.}$$

But, to show the immense advantage of putting a roof over the reservoir, and thereby preventing the sun's rays acting on its surface, I assume that by so doing we reduce the temperature of the cooling water from 95° to 75°, then we could do the same work with one-half the quantity of water, thus :—

$$\frac{1114 + 0{\cdot}3 + 160 - 115}{115 - 75} = 26\text{lbs. of water for every lb. weight of steam.}$$

This showed what an important item the temperature of the water was when used for condensing steam, and also showed the double advantage in a plant of this kind if the surface of reservoir was roofed over.

The temperature of the cooling water in refrigerating machines played the same important part in their cycle of operations, and machines which could do a certain amount of work with all ease with the cooling water at 65° would be practically useless where the temperature was 85° to 90°, and the fact of our want of knowledge in this respect has cost Australians many thousands of pounds.

## EXHAUSTION.

To find the amount of water required to condense steam, by the formula as set down in our text-books, was somewhat confusing, consisting of a series of equations, which, although correct enough, had a lot of unnecessary gear about them, whereas they could be explained in a brief and simple manner, which would commend itself to a practical mind.

The greatest efficiency of any steam engine depended almost entirely on the difference of temperature between the initial and exhaustive pressures; the higher we could get the steam pressure and the lower the exhaustive pressure must of necessity represent the maximum efficiency of our machinery. As was well known, we have of late years doubled, and in many cases trebled, the working pressure of the steam, and the tendency was to still increase, but we could not alter the pressure of the exhaust; that was a fixed point, or at all events if it was not it ought to be, because it was that point where we took all the possible work out of the steam before we let it go, and this held good for all condensing engines and for all pressures; the point of exhaustion should be the same for 80lbs. and 160lbs.

Such being the case simplifies the rule for finding the required amount of water to condense steam, because the amount of heat in the steam was always the same. Taking into consideration that the vacuum was never perfect, the back pressure being, say, 2 lbs., it would be very near actual results to assume the exhaust pressure to be constant at 8 lbs. absolute, that was 8 lbs. below the atmospheric line, where its temperature would be 175° F. This would give us a constant of 1160, representing the total heat in the steam. Then, in all cases, the rule would be very simple and easily remembered, viz.—

$$\frac{1160-\text{Temp. of hot well.}}{\text{Temp. of hot well}-\text{Temp. of cooling water.}}$$

Example—Temp. hot well 120°
Temp. cooling water 60°

Find quantity of condensing water—

$$\frac{1160-120}{120-60} = 17\tfrac{1}{3} \text{ lbs. water for every lb. of steam.}$$

## EXPANSION.

Referring to the author's description of the pumping plant, the engine had to deliver 10,000 gallons per hour, against a head of 132ft., and the steam had to travel a distance of 2000ft., making it imperative to have provision for the amount of expansion due to that length. For many steam plants this important provision was entirely neglected, causing excessive "wear," besides being annoying and expensive—added to which, any attempts to get rid of the evil was invariably unsatisfactory. (Helensburgh Colliery, Steam pipes ½in. longer when hot than cold), 25ft. long, temperature 316°, pressure 70°, normal temperature 70°, expansion ½in.

In the Childers plant the steam pipe was 2000ft. long, and the expansion, due to the increased temperature, amounted to 30in.; that was, the pipe was 30in. longer with steam inside of it than in its normal condition; and it might not be out of place to explain how this provision for the expansion of steam pipes should be treated:—

Assume the normal temperature to be 85° F.

Assume the steam temperature to be 270° F.

Co-efficient of expansion for wrought iron = ·00000681.

Length before expansion = 2000 + 12 = 24,000in.

Increase of temperature 270—85 = 185° F.

∴ 00000681 x 24000 = ·16344000.

And ·16344000 x 185° = 30·2in., the amount of expansion. Probably the temperature difference was more than 185°, which would increase the expansion; but, as this 30in. was for a straight pipe 2000ft. long, no doubt a certain amount would be taken up on the bends.

One of the most important of the author's statements, and one which, in his absence, Mr. German would perhaps kindly explain, was the necessity of having to pump the water up to a height of 132 feet, in order that it might be sufficiently cooled before falling to the reservoir level. The water was passed through holes ¾ in. in diameter, the pitch of the hole centres being 3 in. Now, it appeared to him the efficiency of cooling the water did not depend so much on the height of fall as on the fineness of division; that was, if the water was forced through a large number of very small holes, converted into a fine spray, the cooling-tower might be dispensed with, because the finer the water particles the greater would be the decrease in temperature.

Mr. German, in reply, said he had been under the impression that there was not very much room for discussion or criticism in the paper, but he was mistaken; and had he known what was to come he would not have moved the adjournment of the discussion. However, he would endeavour to reply, and with regard to the question of cost he could not answer positively, because although attempts were made to keep the cost of the various items in connection with the whole factory separate, as some parts encroached upon other parts, it would be seen that difficulties occurred in separation. The installation, as a whole, cost a little over £5000, and the dam itself a little under £3000. Now, as to whether they had taken into consideration the obtaining of water by other sources, he believed artesian wells in that neighbourhood were a failure, and for dealing with such an immense amount of water it would be out of the question. In considering whether water should be obtained from the nearest permanent supply, it was found some 6 or 7 miles of piping would be needed, also the right to run it through different properties, and it would also entail the services of an engine-driver and fireman at the pumping station; so the idea was abandoned, with the exception of a flying survey being made, so that, in the event of a very dry season, the piping would be laid and the plant installed. As to the pollution of the water in consequence of its being used over and over again, the only pollution that could occur was by the condensing water being mixed with the condensed water, and that was the reason why the surface condenser was put in; the condensed water could thus be separated and run to waste, but experience showed that the condensed water could be mixed with the condensing water if a quantity of that in circulation was occasionally run to waste or pumped on to a small sewerage farm by a pump which also dealt with the various drainage waters of the mill. At first there was some little trouble over polluting Apple Tree Creek, which was the only source of water supply to campers below the site. Mr. Howarth requested figures relating to the temperature of the water after cooling, and also whether they had collected other data, cost of pumping, &c. Well, last season was the first that the contrivance worked, and very little data was obtained in that connection, and he was not aware of special observations being made. As to the cooling of the water below the temperature of the atmosphere, one could understand that for such purposes as cooling butter or other products the engineer must get down to a certain temperature, but it was a different matter when the water was simply used for condensing steam, for the quantity in circulation could be increased to compensate for increase in temperature. He thought the cooling-tower referred to by Mr. Howarth as being fitted with vertical rods would run into a tremendous amount of money, to deal with 50,000 gallons of water per hour, and the speaker did not quite see that any better cooling effect would be got, because, as Mr. Selfe pointed out, the cooling effect was entirely determined by the surface of water exposed to the air, and by the dryness and temperature of that air, which of course regulated the amount of moisture it is capable of absorbing, and he ventured to think that horizontal layers of boughs would hold more water in suspension than vertical rods. But the whole thing resolved itself into a question of efficiency at the least cost, and the speaker thought Mr. Kidd adopted the wiser plan in taking the ordinary bushes that he found growing near the site. Mr. Auldjo had doubts as to whether the best system had been adopted for the cooling of the water, and he advocated a system he had used in connection with a refrigerating machine for butter, but he said that machine was designed to cool 1500 gallons of water per hour.

There was a marvellous difference between 1500 gallons per hour and 150,000 per hour. Moreover, the express desire was to have the apparatus independent of any mechanical appliances or attention, and this was accomplished; and he believed if the size of a fan necessary to produce the requisite quantity of air to take up the quantity of moisture to produce the evaporation necessary, were worked out, it would be found that a very large fan would be necessary. Mr. Auldjo asked why a more economical pumping engine had not been adopted; the reason was, in the first place, that coal at the mill was cheap (he believed it only cost ten shillings per ton), and only a small quantity was used, the megass from the crushed cane being the principal item of fuel; and again and more especially because, in all sugar works economical engines were of relatively little value, because the steam that was passed through the engines was not lost, and only loses sensible heat, not the latent heat, and is then used in the evaporating vessels for heating and concentrating the juice; and that was the main reason why compound or condensing engines wre not used in sugar mills. The speaker defended Mr. Kidd in reply to Mr. Selfe's statement, that Mr. Kidd was wrong in saying there was no data to show the surface or evaporation required to produce the cooling effect, and believed that Mr. Selfe must have misunderstood Mr. Kidd, who did not at all ignore the laws that exist in connection with that matter. What the speaker believed he intended to convey was, that in such a climate as Queensland there was no data to show the average temperature, the average dryness of the air, and of course, in connection with that also comes in the average force of the wind, because, taking a day with a given temperature, and a given humidity, if it was a still day the cooling effect would be very different to the same conditions occurring, with the exception of a strong wind. Mr. Selfe had also mentioned the apparent waste of horse-power in the plant, and said it required 66 horse-power to lift the water the 80ft. necessary; but the elevation of the water for cooling purposes was actually only 40ft., because the other 40 was required to produce the head necessary to force the water through the surface condenser. Mr. Selfe also pointed out that the screens were arranged the wrong way; but, with all due deference to him, he had made a mistake, and taken it that these shutters or screens were put to the windward side, with the result that the wind would be forced in a downward direction; but the screens were only placed on the leeward side so that the water blown on to them simply trickles back into the tank. According to some Cuba plans he had seen, precisely the same principle had been carried out (with the exception that the tank was on the ground), of course, involving a second pumping. There the same kind of tower and bushes were used, showing that engineers engaged in the same class of industry in other parts of the world had pretty well came to the same conclusion as to what was necessary and most efficient, within the bounds of economy. In reply to Mr. Fitzmaurice as to what became of the water if the pumps broke down, he would, first of all, say that they had been quite free from such breakdowns so far; but, in the event of such a mishap, there was a sluice valve between the tank and the surface condenser; consequently, the only water that would run to waste would be that in the cooling tower tank which would be above the level of the condenser tank. The only item to which he need reply in Mr. Cruickshank's contribution was that wherein he mentioned that if it were possible to reduce the temperature of the water to 75deg. instead of 95deg., only half the quantity of water would be required. This possibility rested with the weather and with cold dry winds. No doubt, they only used half the quantity required when warm and humid conditions obtained, but they had naturally to make provision for the most unfavourable conditions.