Water-Power in the British Empire.[1]

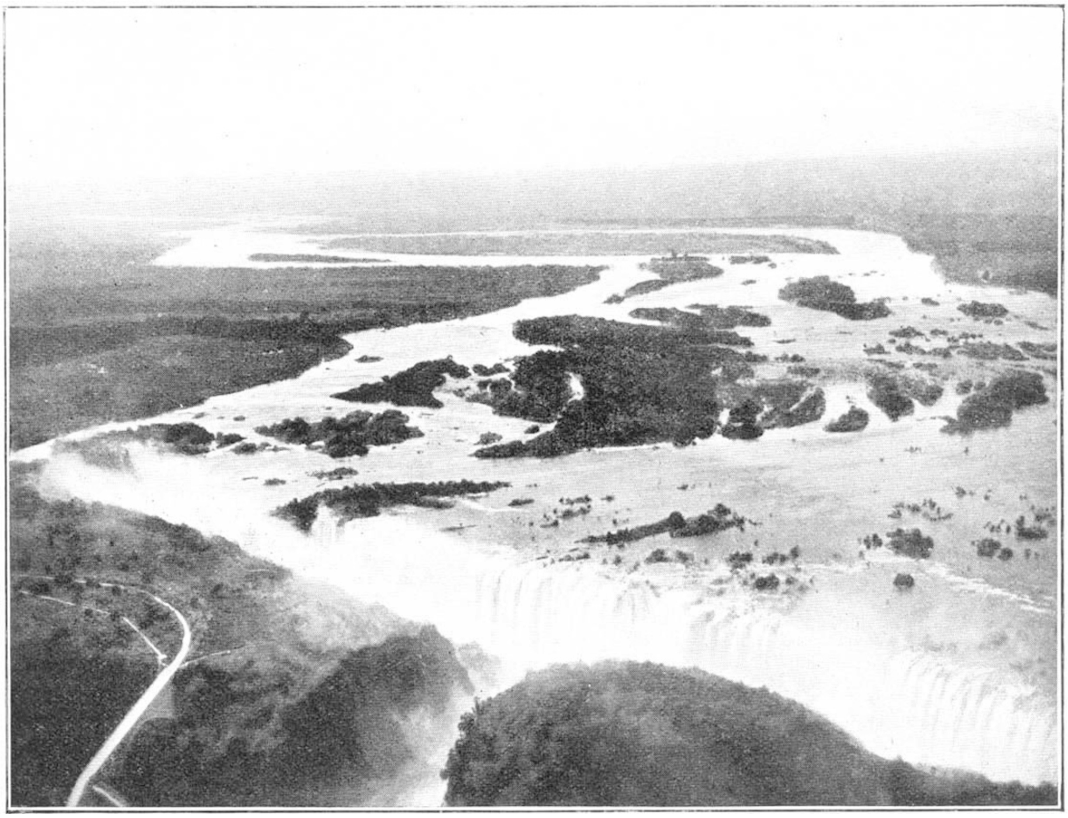
By THEODORE STEVENS.

THE Water-Power Committee of the Conjoint Board of Scientific Societies in its various reports has ably summarised the information on water-power available throughout the British Empire, and the Board of Trade Water-Power Resource Committee and Sub-Committee have dealt with the British Isles in a similar way. Canada has done more measuring of those resources than any other part of the Empire. Canadian water-powers in service, catalogued in Water Resources Paper Number 27, numbered, in 1920, 336 developed water-powers. Of these the summary, arranged by me under the different heights of falls, shows

43 were working with heads of water between 5 and 10 feet;
47 at heads between 11 and 15 feet;
84 " " " 16 " 30 "
84 " " " 31 " 70 "

With these figures before us, development of any head of water that may be available can be justified from past experience; but it is a great mistake to conclude that sufficient power can be developed from a stream until all the details of the problem have been fully studied.

There have been, within the last twenty years, water-plants installed in twenty different places, in every one of which after the capital was spent there was a rude awakening to the fact that the quantity of water necessary for the work undertaken was not available. A total of 25,000,000*l*. has been spent in those twenty places, and has proved financially unprofitable. Much more capital has elsewhere been profitably invested. Many other water-powers have proved successful. Enough has been said to show that reasonable caution necessitates efficient preliminary study before capital is invested.



[*Photo by Col. Sir H. A. Van Ryneveld, K.B.E.*

FIG. 1.—Victoria Falls, Rhodesia; view from the air.

The river at the fall is 1 mile wide and drops into a narrow gorge 400 feet deep.
The large model of Victoria Falls in the Imperial Institute, South Kensington, London, aids one to visualise this configuration.

Another note of caution refers to the distance that it is economical to transmit power. For example, it would not pay to generate hydro-electric power to supply a lighting load 75 to 100 miles away, if there is a coal-mine near the consumers' end of the transmission line; nor is it practicable to undertake to supply separate villages and farms on the line of a high-voltage transmission, because it costs many thousands of pounds to tap power from a high-voltage line, and the small consumption in village and farm cannot possibly pay the interest on this expenditure. It would be unnecessary to make such comments if this uneconomical arrangement had not been seriously advised by

[1] Substance of two lectures delivered at the Royal Institution on March 1 and 8, when illustrations of the important waterfalls in each part of the Empire were shown.

engineers whose experience evidently did not include such electrical details.

Seventeen years ago it was suggested that Victoria Falls (Figs. 1 and 2) would supply Johannesburg, and I have preserved a copy of the original prospectus of the company, including a map of the proposed transmission over a distance of 600 miles from the water-power across and into coal-mining districts. The company which was then floated has paid handsomely; but it wisely burns coal and says nothing about water-power. Even the hotel at Victoria Falls is lit by an oil engine. Similarly, if an examination is made of the super power zone in the United States, which embraces the great industrial area in the Eastern States, it will be found that it approaches within 200 miles of Niagara Falls, where many millions of horse-power run to waste, but it is not suggested that power should be derived from Niagara for that super power zone.

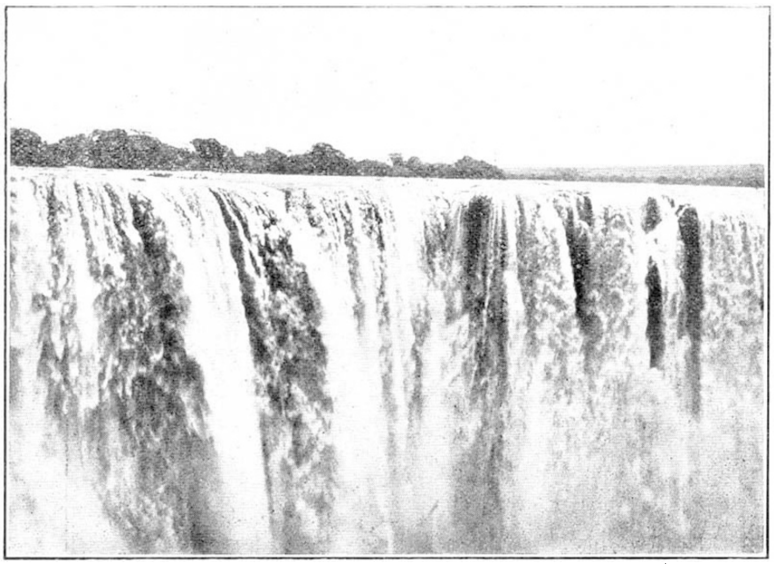


Fig. 2.—Victoria Falls; part of main falls. By courtesy of the British South Africa Company.

It is also true that Niagara power is delivered 270 miles from the Falls. The selling price (by Government, without profit) in bulk to the towns at that distance is three times the selling price for similar power near the Falls. There is always an excess of water at Niagara Falls. Under other conditions, for example, where summer flow is limited and cheap coal is available, it might be easy to prove that it is cheaper to generate electricity locally from coal than to transmit water-power so far.

Tidal-power fascinates every one who studies it; and when our coal supplies are much nearer depletion than at present, it may be utilised on a large scale. The Ministry of Transport published a scheme (since withdrawn) for developing tidal power on the river Severn, and said that the power was so vast that it exceeded "all the potential sources of inland water-power in the United Kingdom put together." But two and a half times the power proposed for development in the Severn exists in other parts of the British Isles, where it is free from the irregularity due to the variation in the times of the tides, and it can be developed for 5,000,000*l*. less in first cost than the estimate for that tidal power; the estimate, in my opinion, was not half enough to do the work specified.

We might allow this scheme to rest in peace, since the Geddes axe was first sharpened for use on the promoters of it; but, from time to time, it is brought forward as practicable. If one reads the Interim Report on Tidal Power by the Board of Trade Water-Power Resource Committee, it will be seen that nothing more costly than further investigation and study of the complications involved was recommended by that Committee; and the Electricity Commissioners dissociated themselves from any knowledge of the power-house, two miles long, with railway trains using the power-house as an economical bridge across the river.

We have an example of a corporation electricity supply being changed from a financial burden on the rates to a satisfactorily profitable undertaking in the report of the Chester electrical engineer, Mr. S. E. Britton, by utilising a small head of water (which varies from nothing up to 8·5 feet, because the tide comes up to the water-power plant's discharge). In seven years, on a capital of 56,000*l*. in steam-plant, there has been a relative loss of 15,000*l*.; while 18,000*l*. capital invested in the water-plant has shown 82,000*l*. profit, leaving a net profit of about 67,000*l*.; but it is essential to realise that this water-power cannot be utilised for a satisfactory statutory supply of electricity in Chester without the steam-plant to produce current from coal when the water-power is not available (due to high tide or to insufficient flow in the river).

Shawinigan in Canada is an example of a beautiful waterfall concerning which, I believe, it was an American who wrote:

At every waterfall two Angels stay,
  One clothed in rainbows, the other veiled in spray.
The first, the beauty of the scene reveals;
  The last revolves the mighty water-wheels.
And there those two fair sisters ever stand,
  Utility and Beauty, hand in hand.

To-day, instead of standing to be admired, "Beauty" is to be found voluntarily undertaking some useful work.

The water at Shawinigan Falls now flows down inside pipes. Where, in the days of Beauty, only an occasional sportsman visited the falls, is to be found to-day a town of 12,000 inhabitants, amply provided with work and wages by the water-power which is utilised for various electro-chemical manufactures, as well as for supplying the cities of Montreal and Quebec with electricity.

In Ireland the writer carried out surveys of the power available in the largest rivers, for the Irish Hydro-Electric Syndicate and for the Water-Power Resources of Ireland Sub-Committee under the chairmanship of Sir John Purser Griffith, and has shown that it would be practicable in an average year thus to supply a demand three times as great as the present demand in the whole of Ireland for electricity, and has recommended and shown the economy of linking up this supply to all important towns and cities; utilising existing steam-electric stations to supply current when, owing to drought, one summer's flow of the rivers is too far below the average summer flow. The combination is like that at Chester, but on a much larger scale.

Suppose we allocate part of each of the rivers Shannon and Erne to the manufacture of carbide and of nitrogen fertilisers and operate this plant as fully as the flow of water permits; with an average output we could make in a year fertilisers containing 20,000 tons of nitrogen. Each of these works would be of the size recommended as economical by the Nitrogen Products Committee of the Ministry of Munitions.

It is not definitely known how much nitrogen fertiliser can be utilised within Ireland; but there are markets for carbide and for nitrogen fertilisers outside Ireland, so any excess over home requirements could be exported at a profit.

The nitrogen in various compounds used in a year in the world amounted to 694,600 tons[2] pre-War and 1,219,000 tons post-War (1919). There is nothing excessive in recommending fixation in Ireland of 3 per cent. of the world's annual pre-War consumption of nitrogen.

There would be work throughout the year, but more people employed at the chemical works in winter-time than in summer. It is well known that about 10,000 workers leave Ireland every summer to do farming in Scotland and England and return to their more economical life in Ireland during the winter-time. For some of those there would be thus provided winter work in their own country; while, of course, there would be employment throughout the year for an appreciable number.

There are nitrogen fixation plants near Niagara and at various other places in the world. About half of the pre-War consumption of nitrogen was in the form of native nitrate of soda. Among the many important applications of water-power, the one in Tasmania, where the Electrolytic Zinc Co. of Australasia, Ltd., utilises 30,000 horse-power from the Tasmanian Government Plant for the preparation of high-grade zinc, is worthy of especial mention.

More attention should be paid to the selection of industries that require large amounts of power, and to their establishment at sites where suitable water-power is available. We cannot recall too often the history of Niagara's development. Before electricity was a commercial form of energy, capital was invested (during the years 1853 to 1861) in making provision for direct water-power; in 1861 it was ready, but it ran to waste for ten years before the first consumer arrived in 1871. It was not until 1894 (forty-one years after the commencement referred to) that a profitable amount of power was utilised. Water-power is the cheapest form of energy when fully utilised twenty-four hours in the day.

[2] American Electro-Chemical Society's Proceedings, Volume 34.

Obituary.

PROF. J. D. VAN DER WAALS.

WITH Johannes Diderik van der Waals, who died on March 8 at Amsterdam, at eighty-five years of age, one of the great figures in the history of modern physics and physical chemistry has passed away. His thesis on the continuity of the liquid and gaseous state was a revelation in the study of fluids, the remembrance of which was to glorify the golden jubilee of his doctorate next June, and after establishing it he continued for some forty years to apply his efforts to the same subject, marking the steps of his success by further brilliant discoveries. When the Nobel Institute honoured this lifework, van der Waals was still occupied rounding off the comprehensive views science owed to him. For about half a century he was in the front of the workers in the domain he had opened. In the ten years which separate us now from then his forces began to give way, and later bodily and mental sufferings, borne with modest resignation, set in. At last, only short visits allowed us to show to the venerated and beloved friend, whose heart we felt remained unchanged, what he had done for us.

Van der Waals was born on November 23, 1837, at Leyden. He was a self-made man who took advantage of the opportunities offered by the University which he later honoured by his curatorship. It was not until he was thirty-six years of age that he wrote his thesis. With it he himself opened the period of Dutch science, which his elder friend Bosscha and he hoped to be one of the results of secondary education. In 1877, van der Waals became a professor at Amsterdam, and began to exert his great influence on the development of Dutch physics. One of the characteristics of his highly admired teaching was the introduction of Gibbs's great work to the chemists. I vividly remember as an example of it how Bakhuis Roozeboom, to whose first experiments the Leyden physical laboratory had been in the position to give some help, obtained results, which were inexplicable until van der Waals came to give him the key to it in Gibbs's doctrine of phases, his deep insight clearing the way for Roozeboom's brilliant work on the phase rule.

Very much was done by van der Waals for the Royal Academy of Sciences at Amsterdam. For twenty-four years he was the soul of the Board, and in 1896 he even accepted the secretaryship of the Academy, a post which he filled until 1912. Here as everywhere else he showed a never-failing unselfishness and high conception of duty. We owe to him the modern form of the Proceedings and their English translation, which he directed, both with an incomparable energy. The great efforts he bestowed on these periodicals have been well rewarded by the effect their stimulating influence had on Dutch science.

The scientific work of van der Waals forms a monumental whole of a special style. Characteristic of it is the intuition by which he introduced happy simplifications and approximations leading to a high degree of qualitative agreement of his theories with Nature, which in the case of the law of corresponding states rose even to a surprising quantitative approximation.