Canadian Hydro-Electric Power Development.

By Dr. BRYSSON CUNNINGHAM.

I.

DURING a recent tour in Canada the writer, who had on a previous occasion seen Niagara and the Chippewa-Queenston installation, was able to investigate more widely, though admittedly in a superficial manner, the present stage of hydro-electric power development in the province of Quebec, where he visited power-sites and waterfalls at Shawinigan, Grandmère, La Gabelle, and Montmorency. He also took the opportunity of discussing the situation with officials of the Shawinigan Water and Power Company at Montreal and of the Water Power Branch of the Department of the Interior at Ottawa. The following notes of his observations, combined with information obtained from official sources, may be of interest to readers of NATURE.

The vital importance of water power to Canada in the development of its industries is a fact not readily appreciated in Great Britain, where water power supplies are relatively of negligible proportions and an abundance of coal for steam driven plant fully compensates for the deficiency. In Canada, the reverse is the case ; or rather, to speak with greater precision, it is the case in the more highly developed and most populous provinces of the Dominion, namely, Quebec and Ontario. Neither of the provinces in question is favoured with coal deposits ; at any rate, none of economic value has been found, or seems likely to be found : on the other hand, both have numerous waterfalls, most of them capable of development as sources of power at a reasonable and remunerative outlay.

It has been computed that there is some eighteen and a quarter million horse-power of 24 hours availability, and 80 per cent. efficiency, at ordinary minimum flow, in the whole of Canada. Of this, nearly twelve million h.p., or say two-thirds, is located in the provinces of Quebec and Ontario, the former having the preponderant share of seven million h.p. If the figures be referred to the basis of ordinary six months flow, the total for the Dominion is raised to 32 million h.p., and the proportions of Quebec and Ontario are 11,640,000 h.p. and 6,808,000 h.p. respectively. The actual water-wheel realisation is fully thirty per cent. in excess of this. These figures give some idea of the vastness of the resources available, especially when compared with the mere million h.p. which represents the total estimated resources of the British Isles. It must not be assumed that the figures, however, are in any sense complete. Indeed, they represent the minimum possibilities. Many rapids and falls in Canada, of greater or lesser power capacity, are scattered over rivers and streams which are not yet recorded and can only become available for classification as detailed survey work is extended and carried out. This is particularly true of the less explored northern districts of the Dominion. Moreover, full consideration has not yet been given to those power concentrations which may be feasible in rivers and streams of moderate gradient with the aid of dams and impounding works. Altogether, it must be admitted that the natural water resources of Canada are of a very high and even stupendous order, amounting on a

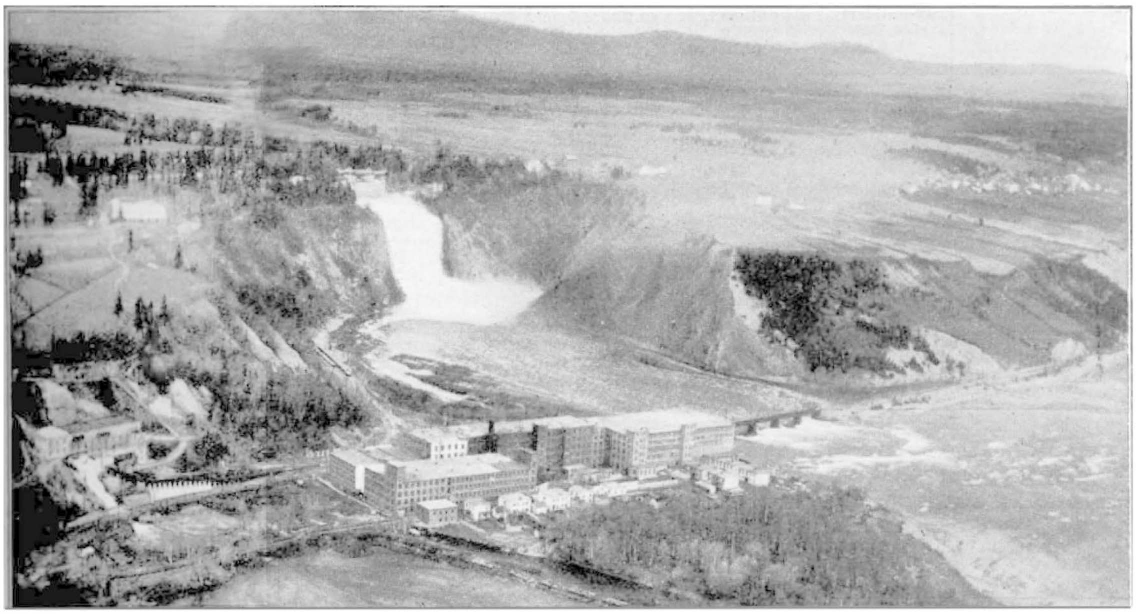

Photo.] [Fairchild Aerial Survey Co. (of Canada), Ltd.

FIG. 1.—Montmorency Falls and Power Station. The Falls are 274 ft. high ; 114 ft. more than Niagara.
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conservative estimate to fully forty million horse-power.

Out of the impressive total, whatever it may be, so far the actual utilisable turbine installations established at the present time yield only 4½ million h.p.—a very small proportion, barely eleven per cent. of the total.

It may be of interest here to insert a full table of the estimated provincial distribution of water power as corrected up to Jan. 1 last, and issued by the Water Powers Branch of the Canadian Department of the Interior.

AVAILABLE AND DEVELOPED WATER POWER IN CANADA (JAN. 1, 1927).

Province.	Available 24-hour power at 80 per cent. efficiency.		Turbine Installation (h.p.).
	At ordinary min. flow (h.p.).	At ordinary 6 months flow (h.p.).	
British Columbia	1,931,142	5,103,460	460,562
Alberta . .	475,281	1,137,505	34,107
Saskatchewan .	513,481	1,087,756	35
Manitoba . .	3,270,491	5,769,444	227,125
Ontario . .	4,950,300	6,808,190	1,790,588
Quebec . .	6,915,244	11,640,052	1,915,443
New Brunswick .	50,406	120,807	47,231
Nova Scotia .	20,751	128,264	65,702
Prince Edward Island . .	3,000	5,270	2,274
Yukon and North-west Territories	125,220	275,250	13,199
CANADA . .	18,255,316	32,075,998	4,556,266

The value of the 4½ million h.p. already developed may be gauged from the fact that it is found that each installed h.p. is capable of effecting an annual saving of 6 tons of coal, or a total of 27 million tons of coal per annum. With the increasing economies which are taking place in the production of power from coal, this valuation of 6 tons per h.p. will no doubt require adjustment from time to time, but at present it represents a fair and reasonable equivalent. To the provinces which have to import their coal for industrial purposes, the economy is of significant proportions.

It is scarcely to be wondered at, in these circumstances, that the exploitation of available water power sites in Canada is proceeding steadily and even rapidly. To give one example only, five years ago (on the occasion of the writer's previous visit to Canada) the River Saguenay, running from Lake St. John to the River St. Lawrence, was a natural, unregulated stream, flowing through a remote and primitive district. In the interval, some 450,000 h.p. has been developed at Isle Maligne, a station on the river where a fall of about 100 ft. has been utilised, and preparations are now in hand to instal a second power house at Chute-à-Caron, where the fall is 200 ft., with a corresponding availability of power. Works and mills are springing up along the banks, and a new industrial town is projected at Arvida.

During last year (1926) the total horse-power installed throughout the whole of the Dominion was 265,838, but while this is a substantial figure in itself, it fails to take into account many constructional activities which had not reached their final stage. A number of these are nearing completion and will shortly add 1,700,000 h.p. to the Dominion total, while others in active prospect indicate a further addition of at least one million h.p. The capital invested, or involved, in these undertakings cannot be put at a less figure than 270,000,000 dollars.

That progress in the future is likely to be accentuated may be inferred from the consideration that,

DEVELOPED WATER POWER IN CANADA.

Province.	Turbine Installation in H.P.			Total.	Population, June 1, 1926.	Total Installation per 1000 population.
	In central electric stations.	In pulp and paper mills.	In other industries.			
1	2	3	4	5	6	7
	H.P.	H.P.	H.P.	H.P.		H.P.
British Columbia . .	318,179	80,500	61,883	460,562	568,400	810
Alberta	33,520	..	587	34,107	607,000	56
Saskatchewan	..	..	35	35	823,000	0·04
Manitoba	210,725	..	16,400	227,125	638,000	356
Ontario	1,508,266	174,548	107,774	1,790,588	3,145,600	569
Quebec	1,546,692	242,044	126,707	1,915,443	2,561,800	748
New Brunswick . .	25,325	13,003	8,403	47,231	407,200	116
Nova Scotia . . .	31,942	16,636	17,124	65,702	540,000	122
Prince Edward Island .	279	..	1,995	2,274	87,000	26
Yukon and North-west Territory	10,000	..	3,199	13,199	12,300	1,073
CANADA	3,684,928	526,731	344,107	4,556,266	9,390,300	485

Column 2 includes only hydro-electric stations which develop power for sale.
Column 3 includes only water power *actually developed* by pulp and paper companies. In addition to this total, pulp and paper companies purchase from the hydro power central stations totalled in Column 2, horse power estimated at about 425,000 h.p., making a total of about 951,000 h.p. actually used in the manufacture of pulp and paper.
Column 4 includes only water power *actually developed* in connexion with industries other than the central station and pulp and paper industries. These industries also purchase blocks of power from the central stations totalled in Column 2.
Column 5 totals all turbines and water wheels installed in Canada.
Column 6, population at June 1, 1926, as estimated by the Dominion Bureau of Statistics.
Column 7 averages the developed water power per 1000 population.

as stated in the Government Report dated Mar. 1 last, the consistent earning power of the various hydro-electric organisations, coupled with the fact that the output of new stations is absorbed almost as soon as it comes on the market, has created a favourable impression in capitalist circles and established a public confidence which is demonstrating itself in the inception of wider and more expansive undertakings. Of the 265,837 h.p. installed during 1926, more than 219,000 h.p. was destined for public distribution through the medium of central electric stations. Pulp and paper mill organisations installed 44,760 h.p. during the year, mainly connected to electric generators, and they will purchase a considerable portion of the additional installation of the central electric stations. Installations other than for central electric station purposes and in pulp and paper mills, totalled only 2072 h.p., of which 2000 h.p. was for electrochemical reduction.

The uses to which the existing installations throughout Canada are put, indeed, continue to follow on general lines the apportionment in the foregoing paragraph. Preponderant, and of growing importance, is the distribution of hydroelectricity through the medium of central electric stations, which account for fully 80 or 81 per cent. of the total. Next comes the pulp and paper mill industry, absorbing about $11\frac{1}{2}$ per cent. of the total power, apart from the large purchases which the mills make from the central stations themselves. General industrial enterprises, such as electrochemical reduction, lumber manufacturing, flour milling, grain grinding, water pumping, etc., account for the balance of $7\frac{1}{2}$ per cent.

The table above from the Government report is of interest in showing these allocations, and also the total hydraulic installation per thousand of the population, a feature which bears on the capacity for industrial output of the workers of the Dominion. The high average of 485 h.p. per 1000 population enables Canada to assume a position of importance among the nations of the world in *per capita* utilisation of water power.

Some Colouring Agents in Glasses and Glazes.[1]

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BEFORE dealing with the colours and effects produced by ferric oxide in glasses and glazes, let me direct attention first to the different shades of colour which can be seen in varieties of the oxide itself. These range from a reddish yellow through brick reds, bright reds, to a rich brown red and almost to a black. Some specimens also have almost a bronze-like appearance. The range of colours produced when ferric oxide is used as a colouring agent for glasses and glazes is practically as great. It is doubtful if the colours produced by ferric oxide are due to compounds of this oxide with the other constituents of the glass. Without going into elaborate detail it is somewhat difficult to give adequate support to this statement. Perhaps the simplest way of dealing with it is to take the behaviour of ferric oxide in lead glasses, frequently described as flint glasses. There are light flints and dense flints. In the light flints there is always a notable quantity of an alkali such as potash or soda along with the lead oxide. In the dense flints the proportion of alkali is decreased and the proportion of lead oxide is increased.

Now, taking three such glasses as examples, having specific gravities of 3·2, 3·8, and 4·8, it is possible to add a known, but small, quantity of ferric oxide to the first glass and still to produce a glass having no detectable yellow colour to the eye. The same amount of iron added to the second glass will give a noticeable yellow colour, and added to the third glass will give a marked yellow colour. The glass of specific gravity 3·2 contains a notable proportion of alkali, and there is reason to believe that this either promotes the formation of a compound of ferric oxide with the alkali or the formation of a double silicate, either sodium ferric silicate or potassium ferric silicate; such compounds appear to be colourless. If the quantity of iron be increased, then a colour can be produced in the light flint, and, by increasing the percentage of ferric oxide to 5 per cent., a fairly strong yellow colour is produced. With 10 per cent. of ferric oxide in the same glass the colour is a deep brownish red when looking through a thickness of about 3 mm. With 20 per cent. of ferric oxide an even richer red colour can be seen when looking through a thickness of $\frac{1}{2}$ mm.; but in thicknesses of 1 mm. or more the glass is practically opaque. When the percentage of iron is raised much higher, some ferric oxide crystallises out from the glass on cooling, and with 40 per cent. of ferric oxide the small crystals dispersed through the glass can be seen with a hand lens. With the denser flints, containing a lower percentage of alkali, colours similar to those described above are produced with much smaller proportions of ferric oxide.

A reasonable explanation of this would be on the same lines as the suggestions made in dealing with cuprous oxide and metallic copper, namely, that the light yellow colour is due to a small amount of free ferric oxide dispersed in the glass as extremely fine particles; the transparent deep yellows and brownish reds would represent a greater concentration of ferric oxide similarly dispersed, possibly also, as the percentage of ferric oxide gets higher, as somewhat larger particles. In the 20 per cent. glass mentioned the particles are still too small to be seen, but in specimens of lead glass containing nearly 30 per cent. of ferric oxide, fine clouds of almost irresolvable particles can be seen in the microscope.

Leaving the subject of lead glasses coloured with

[1] Continued from p. 266.