posterior aspect of the hemisphere (Fig. 6 represents the pole of the left hemisphere) three semilunar sulci—lunatus, polaris superior, and polaris inferior—may often be seen arranged in a trefoil or shamrock-leaf pattern (grouped around the calcarine sulci in the axis of the area striata). The rapid expansion of the lateral part of the area striata to afford cortical representation of the macula is responsible for the formation of opercula bounded by these three semilunar sulci. Hence the presence of this cortical shamrock-pattern affords definite evidence of the position and extent of the macular area. It is so situated in relation to the other cortical areas as easily to be linked up with them in the functions of wider vision, which involve the activities of the cerebral hemisphere as a whole—the process of mind-building upon the foundation of macular vision.

It is a matter of such vital importance not to overlook the part played by action in mind-making

that the argument may be emphasised once more, When under the guidance of vision some delicate manipulation is performed, in addition to the success or failure of the mechanical operation, and the emotions of satisfaction or disgust which the results of the attempt and the attendant circumstances excite, the action itself starts a series of impulses from the joints, muscles, tendons, and from other parts of the body, which integrate the whole process with the intimate texture of the individual's consciousness and personality. The appetites and feelings which prompt the action, no less than the discriminative experience and knowledge which play their part in determining whether it is worth doing and how to do it, become associated with the activities of the whole organism during the progress of the movement. It is no longer a mere matter of muscular contraction under visual control, but a complex process of integration of experience and of creating understanding and intellect.

Canadian Hydro-Electric Power Development during 1929.

By Dr. BRYSSON CUNNINGHAM.

THE recent issue of two reports¹ by the Canadian Government Water Power and Reclamation Service enables a survey to be made of the expansion which has taken place during the twelve months ended Dec. 31 last in the development of hydro-electric power in the Dominion. The review made in NATURE of July 27 last year, on the statistics then available, showed a very striking and rapid rate of progress. This progress has been substantially maintained and important activities are reported from practically every province. The total capacity of new installations brought into operation during 1929 amounts in round figures to 378,000 horse-power, bringing the aggregate for the whole Dominion to 5,727,162 horse-power, as compared with 550,000 h.p. and 5,349,232 h.p. respectively, for the year 1928.

Table 1 shows the available and developed water power of Canada as determined to Jan. 1, 1930. The available power is scheduled in columns 2 and 3 under two heads according to the period of availability. These figures are based on a computation of data relating to rapids, falls, and power sites generally, of which the actual fall or the possible head of concentration is definitely known, or, at least, well established. There are many other rapids and falls of greater or less capacity scattered up and down the country which are not yet included in the register and can only become available for tabulation when the necessary survey work has been undertaken and completed. This is particularly the case in the northern parts of the Dominion, where much exploration remains to be done. Moreover, there are possibilities of power concentration on rivers and streams of gradual gradient which have not been taken into account, except at such selected points as have been the objects of actual study and observation. Altogether, as a record of potential resources, the

figures in columns 2 and 3 may be looked upon as minimum values. Indeed, the basis of valuation itself is appreciably below the standard of development obtained in cases of actual installation by so

TABLE 1.—AVAILABLE AND DEVELOPED WATER POWER IN CANADA, JAN. 1, 1930.

Province.	Available 24-hour power at 80 per cent efficiency.		Turbine Installation (h.p.).
	At Ordinary Min. Flow (h.p.).	At Ordinary Six Months Flow (h.p.).	
British Columbia	1,931,000	5,103,500	559,792
Alberta . . .	390,000	1,049,500	70,532
Saskatchewan .	542,000	1,082,000	35
Manitoba . . .	3,309,000	5,344,500	311,925
Ontario . . .	5,330,000	6,940,000	1,952,055
Quebec . . .	8,459,000	13,064,000	2,595,430
New Brunswick .	68,600	169,100	112,631
Nova Scotia . .	20,800	128,300	109,124
Prince Edward Island . . .	3,000	5,300	2,439
Yukon and Northwest Terr. .	294,000	731,000	13,199
Canada . . .	20,347,400	33,617,200	5,727,162

much as 30 per cent. If the necessary correction be applied, it will be found that the present recorded water power resources of the Dominion will permit of turbine installations aggregating about 43,700,000 horse-power.

The actual installation to the end of 1929 in water wheels and turbines, as shown in column 4, amounted to 5,727,162 horse-power, representing slightly more than 13 per cent of the recorded potential resources.

The progressive development which has taken place since the beginning of the present century is best illustrated by a diagram, and the curve shown in Fig. 1 is remarkable not only for its continuous

upward trend but also for the increasing degree of steepness which characterises its progress. It is

FIG. 1.—Growth of water-power development in Canada, 1900-30.

surprising to realise that thirty years ago hydro-electric installations in the Dominion did not amount to one quarter of a million horse-power.

Obviously it is impossible in the space at disposal to allude in any detail to the various installations which have materialised during the past year. A few observations on one or two stations of outstanding importance is all that may justifiably be attempted in this brief review of the general situation.

The province of Quebec led the way with an addition of more than 208,000 horse-power brought into operation, including chiefly the new plant (72,000 horse-power) of the Montreal Island Power Company on Des Prairies River, near Montreal, and additional units to the existing stations of the Gatineau Power Company and

the Shawinigan Water and Power Company. The Gatineau Power Company added fourth units of 24,000 h.p. and 34,000 h.p. respectively to the stations at Farmers Rapids and Chelsea Dam, illustrated in NATURE of July 27, 1929. A third station on the same river at Pagan Falls, a view of which is shown in Fig. 2, has a present equipment of 204,000 horse-power, which is shortly to be increased to 272,000 horse-power. The same Company also completed the construction of a storage dam at Cabonga Lake, an important upper tributary of the Gatineau River, providing a reservoir with a capacity of 45 thousand million cub. ft. This reservoir is the property of, and is now being operated by, the Quebec Streams Commission in conjunction with the Baskatong reservoir above the Mercier dam, with a capacity of 100 thousand million cub. ft., located lower down the river. The Shawinigan Water and Power Company added a 43,000 horse-power unit (eighth in succession) to No. 2 Shawinigan Falls Station (vide NATURE, Sept. 3, 1927).

Important projects are in hand at Chute-à-Caron on the Saguenay River, where four units of 65,000 h.p. each are about to be installed, and at Beauharnois, on the St. Lawrence, immediately above Montreal, where an initial installation of 200,000 or possibly 350,000 h.p. is projected before the end of 1932. This latter outstanding undertaking includes a diversion canal for power and navigation, approximately 15 miles in length. The inauguration of constructional operations by the Governor-General of Canada was referred to in NATURE of Dec. 14, 1929, p. 930, in which some particulars of the project were given.

FIG. 2.—Gatineau Power Company's development at Pagan Falls on the Gatineau River, Quebec. Present installation, 204,000 h.p.; ultimate, 272,000 h.p. By courtesy of the Dominion Water Power and Reclamation Service, Ottawa, Canada.

The province of Ontario includes the renowned Niagara Falls, or, at any rate, a portion of them. During 1929, work was advanced on the installation of a tenth unit of 58,000 horse-power at the Queenston Station; it is expected to be completed this year. Another important development was the completion of the 28,200 horse-power installation of the International Nickel Company of Canada at the Big Eddy Dam on the Spanish River.

Table No. 2 enables an idea to be formed of the distribution of the developed power among the leading industries in the various provinces. Supplies to central electric stations constitute by far the major portion of the consumption and there is every indication that the proportion used for

all kinds, including traction, lighting, heating, and motive power generally. Municipalities and public organisations control 97 of these stations, containing 237 turbines aggregating 1,297,398 horse-power. The remaining 215 stations, with an installation of 581 turbines and a combined capacity of 3,520,088 h.p., are owned by various commercial organisations.

The next most important source of consumption for hydro-electric power in Canada is the pulp and paper industry—the chief manufacturing activity of the Dominion. One of the most conspicuous features of industrial progress in Canada has been the growth of this industry, arising out of the occurrence of enormous supplies of growing

TABLE 2.—DEVELOPED WATER POWER IN CANADA, JAN. 1, 1930.

DISTRIBUTION BY INDUSTRIES AND PER 1000 POPULATION.

Province.	Turbine Installation in h.p.				Population, June 1, 1929.	Total Installation per 1000 Population (h.p.).
	In Central Electric Stations.	In Pulp and Paper Mills.	In other Industries.	Total.		
British Columbia	417,960	81,000	60,832	559,792	591,000	947
Alberta	70,320	—	212	70,532	846,000	83
Saskatchewan	—	—	35	35	886,700	0.04
Manitoba	311,925	—	—	311,925	663,200	470
Ontario	1,616,773	240,880	94,402	1,952,055	3,271,300	597
Quebec	2,238,525	221,160	135,745	2,595,430	2,690,400	964
New Brunswick	83,910	19,778	8,943	112,631	419,300	269
Nova Scotia	77,697	16,008	15,419	109,124	550,400	198
Prince Edward Island	376	—	2,063	2,439	86,100	28
Yukon and North-West Terr. .	—	—	13,199	13,199	12,400	1063
Canada	4,817,486	578,826	330,850	5,727,162	10,016,800	572

Col. 2 includes only hydro-electric stations which develop power for sale.

Col. 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 electric stations totalled in Col. 2 electric energy for power purposes estimated at about 860,000 h.p., making a total of about 1,438,828 h.p. actually used for power purposes in the manufacture of pulp and paper. A considerable amount of off-peak and surplus power is also purchased for use in electric steam boilers.

Col. 4 includes only water-power *actually developed* in connection with industries other than the central electric station and pulp and paper industries. These industries also purchase power from the central electric stations totalled in Column 2.

Col. 5 totals all turbines and water wheels installed in Canada.

Col. 6 shows the population at June 1, 1929, as estimated by the Dominion Bureau of Statistics.

Col. 7 averages the developed water-power per 1000 population.

this purpose will continue to increase. From a percentage of 33½ at the beginning of the century it has grown to more than 84 per cent. A number of factors contribute to this increasing use, notably the extensive economic radius of modern electrical transmission, combined with the fortunate location of water power sites in relation to centres of population and industry without adequate local fuel supplies. The provinces of Ontario and Quebec, as is well known, are entirely destitute of geological deposits of coal. The special adaptation of hydraulic power to central electrical station operations is emphasised by the fact that the last completed central station census, namely, that for the year 1927, shows that more than 95 per cent of the total main plant equipment is in hydraulic generating stations and that this equipment produced almost 99 per cent of the total electrical output.

It is noteworthy that at the present time there are in Canada a total of 312 hydro-electric central stations, possessing an aggregate of 4,817,486 horse-power, distributing supplies for purposes of

pulp wood in close proximity to readily developable water power of a magnitude adequate to provide the large supplies of power essential to the conversion of the raw material into the finished product. The value of this fortunate conjunction and the importance of ample supplies of economically produced power may be gauged from the fact that practically 100 horse-power is required per ton of daily output of newsprint.

Column 4 of Table 2 shows the amount of electro-hydraulic power absorbed in miscellaneous industries, including mining, to which it is an invaluable adjunct in consequence of the prohibitive cost of fuel power. Columns 6 and 7 are of interest in instituting a comparison of power development per head of population. The figure for the whole of Canada, 584 per thousand, compares extremely favourably with that of other countries, being considerably in excess of most and rarely exceeded, or indeed even approached.

¹ Report No. 1353: Hydro-Electric Progress in Canada in 1929; Report No. 1361: Water Power Resources of Canada. (Ottawa: Dominion Water Power and Reclamation Service.)