

other times. Detailed surveys of advantageous power sites, with designs for development projects, should also be included, together with estimated cost of works, installation and operation. Studies of storage and other conservation possibilities should offer a wide field. Most of our streams are characterized by a large seasonal variation of flow and the capacity of a development is often economically limited by the minimum flow; unless storage and artificial regulation of the flow is resorted to, water runs to waste during the greater portion of the year. Artificial storage of water is already provided in several of the provinces, but it should be extended.

Problems Peculiar to Canada

The solution of problems peculiar to Canada should be given attention. One of these is the conveying of the stored water to the point where it is to be used. During the winter season, the formation of ice and other difficulties resulting from low temperature are met with.

Testing and reporting on various classes of hydraulic and generating machinery and auxiliary apparatus, such as governors, regulators, etc., might also come under this head.

While many British Columbia water-powers offer natural high heads, those in the other provinces have, usually, relatively low heads, therefore, research conducive to reduction in cost of low head developments would benefit Canada.

Irrigation and Water-power

The relation between irrigation and water-power development in the western "dry belt" offers conditions dissimilar to those of other countries; these require special investigation. In the United States, an important use of hydro-electric energy is in pumping water for irrigation purposes, and, while this may never become of great interest to Canada, we may anticipate the construction of joint undertakings using the same site and the same works intermittently for irrigation and water-power purposes. Water, which would be used for irrigation only at the periodical recurrence of a dry year, can be utilized for water-power purposes at other times. This is demonstrated by crop results of 1914 and 1915 from the same semi-arid area in Western Canada. The failure of 1914 was changed to a bountiful harvest in the next year, by about eight inches more rainfall in the growing season.

Disposal of Water-powers

The legal aspect of the disposal of our water-powers is important. The general principles incorporated in our legislation have now become fairly uniform in the different provinces, including the leasing instead of disposition of water-power rights in fee, their development and utilization within a reasonable period, and remuneration to the Crown, which latter, however, should not be a principal object in disposing of water-power. These are all sound principles, and should be maintained, but the details should, if necessary, be changed to secure better results. In the eastern provinces, particularly, most of the water-powers in the settled portions have passed to private ownership; many of them are lying idle and are held by the owners for speculative purposes, or to avert competition. Owners on one side of the river have sometimes been prevented from developing by owners of the portion of the fall on the other side of mid-channel. This condition should be remedied, as water-powers in the more settled portions should naturally be harnessed first for

the benefit of industries. Steps should be taken to release water-powers owned by parties having no intention of developing.

Canada's share in all boundary water-powers should be assured. These occur in the more thickly populated and settled portions and are essential to industrial development. They should be fully investigated and definite projects and detailed plans of construction for their development approved. These plans should then be strictly adhered to by prospective users, which would not only assure its proper share to each country, but, particularly, where several concentration sites are possible on the same river, co-ordination and non-interference would be secured. Large enterprises at Niagara, endeavoring to develop additional power, have again directed attention to boundary waters. In every case of original or additional boundary water-power development, Canada's share should be safeguarded before the plans are given approval; otherwise this country might lose, probably forever, a portion of natural power facilities.

Application of Electric Energy

The investigations under the second head relate to the application of the energy derived from our water-powers to an economic end, for the benefit of Canada. While intimately connected with the first, this phase is of even greater moment—the most elaborate system of water-power development would prove valueless if not extended to yield a marketable product. Numerous problems, however, will arise, particularly in connection with the intermittent use of power as applicable to certain industries. This is well illustrated by a hydro-electric plant near Duluth, Minn., where fully one-half of the energy generated is delivered to a single electro-chemical works. Under arrangements to use intermittent power, practically all surplus energy is utilized, resulting in a load factor of about 90 per cent. The chemical company is notified as to the available power and adjusts its furnaces accordingly, thus securing the advantage of a cheap and plentiful supply.

Electro-chemistry and Metallurgy

The use of hydro-electric energy in electro-chemical and metallurgical processes is generally considered the most advantageous use of water-power. These industries, however, comprise many branches, each offering many different processes, and it is essential, through investigation, to ascertain which of these would be of the greatest benefit to Canadian conditions. If known processes are unsuitable, investigation and research should reveal others which will be profitable to this country.

While local conditions may point to the direct application of water-power, such as in the wood-pulp, paper and lumber industries, the use of electricity as a medium should produce the greater development. The intimate connection between the harnessing of streams and the production of electric energy is recognized, and, if the latter is included in our field, as it should be, we have almost unlimited possibilities. Electricity is one of the greatest potent factors of the universe: First, in its distribution, far and near, for the benefit of domestic life, but, perhaps even more so, in its various industrial applications, whether to produce light, motion, chemical action, or various degrees of heat.

Hydro-electric Development

Canada is by no means backward in hydro-electric development. With but few exceptions, all our principal