Care must be taken in such cases to construct the dam of such a height that storage is obtained for the surplus water in rainy seasons, the amount of the storage required depending, of course, on the size of the drainage area and the amount of the rainfall, and, of course, only a certain flow can be obtained. It needs a careful survey to determine the size of the area and a long series of observations of the amount of rainfall to enable the engineer to decide the amount of flow which can be obtained and the size of the dam which it is most economical to construct. In all cases of the draining of streams the question of the damages to flooded areas is one of great importance.

Primary and Secondary Power.—Now, as stated above, the amount of power which can be supplied by a waterfall throughout the year is the power in which we are primarily interested in the case of any water power development. It is, therefore, termed primary power. In many cases when it is not possible to secure a practically uniform flow, the power developed in excess of that which can be supplied regularly throughout the year, and which, of course, is only available at certain times, is applied to certain special uses which do not require a continuous service. This is called secondary power. Similarly as the daily demands of primary power varies from hour to hour excess power is available at certain hours of the day; this is also called secondary power. Thus at Shawinigan Falls the secondary power is used in the manufacture of calcium carbide, while the primary power is used for the supply of light, heat and power to the city of Montreal, as well as to cotton factories, aluminum works, etc.

The Development of Water Power as Compared with Other Uses of Streams.—The International Boundary Waters Treaty between Great Britain and the United States, as ratified in 1909, gives the rules or principles which shall govern the International Joint Commission in determining the order of procedure which shall be observed in the disposition of water privileges as follows:

"The following order of procedure shall be observed among the various uses enumerated hereinafter for these waters and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of procedure:

(1) Uses for domestic or sanitary purposes.

(2) Uses for navigation, including the service of canals for the purposes of navigation.

(3) Uses for power and for irrigation purposes,"

Thus, under this ruling the very valuable power possibilities on such waters as the St. Mary, the Niagara or St. Lawrence Rivers are regarded as of less or only "incidental" value as compared with the primary intention of navigation.

Uses for Which Water Power May Be Economically Employed.—Water powers were of relatively little value in former years, but have now become of great importance owing to the fact that formerly the power developed from a waterfall had to be employed in the immediate vicinity, if at all. Hence many water powers, great and small, which, as is so often the case, were located in comparatively inaccessible regions were valueless.

It is the possibility of transmitting this power to centres where it is required and where is can be economically employed that has attracted to the water powers of the world the special attention which they have received in recent years.

This transmission has been affected by the discovery that it is possible to transform the power of falling water into electric power and, carrying this on wires to distant points with little loss, and there transform this electrical energy again into light or mechanical power.

Long-distance transmission of power by electricity dates from the year 1882, when Marcel Deprez, at the Munich Electrical Exhibition, transmitted about one horse-power a distance of 35 miles to a place called Wiesbach. So marked, however, are the advances which have been made in the science of electrical engineering since that time that it is now possible to carry the energy developed by our water powers for very great distances. The Pacific Light and Power Co., of Los Angeles, Cal., is now transmitting over 100,000 h.p. for a distance of 240 miles. The Hydro-Electric Power Commission of Ontario is transmitting power a somewhat greater distance—242 miles—from Niagara Falls to Windsor. If electric power is carried for a radius of only 100 miles from any centre, it serves an area of over 31,400 square miles. If it be carried for a radius of 240 miles, it covers an area of rather over 180,000 square miles, or somewhat less than half the area of the province of Ontario. A water power of sufficient magnitude can thus be made available to millions of people.

The distance to which electrical energy can be profitably transmitted is governed by the annual charges on the outlay in constructing the transmission lines, and the cost of coal at the point where the electric power is delivered. Some late developments, notably the use of synchronous reactors at the receiving end of the line, have considerably increased the amount of power which can be conveniently transmitted over any one transmission circuit. This new feature will allow of the design of transmission lines to be operated with the most economical loss in the line. Professor Herdt* lately advised the use of such machines for the power plant and transmission line from Point du Bois to Winnipeg for the city of Winnipeg. The capacity of the transmission lines has been doubled by the installation at the terminal stations of synchronous reactors.

Water power thus electrically transmitted may be used:—

(*a*) For the development of mechanical power for every purpose for which such power is required, *e.g.*, factories, mines, railroads, street cars, elevators, etc.

Not only is electrical energy readily applicable to large installations, but it has the enormous advantage over all others in its capacity for ready subdivision. It may be carried to the small shop, to the barn, to the home. Already in cities where electrical power is cheap, it is running the sewing machine, cleaning the floors and doing other heavy work of the household. Similarly on the farm it may do much of the heavy work, both indoors and outdoors. In certain lines of industries, it may be the means which will keep industry in the small shop instead of concentrating it in the large factory.

(*b*) For the production of light. Electric light so produced is practically the only light used in most large cities.

(*c*) Heat. Electric heating has already been employed on a small scale for domestic purposes in cooking, ironing, etc., and will, as the power becomes cheaper and facilities for delivering it are improved, meet with an ever-increasing demand.

But it has opened up an entirely new economic field in the introduction of the electric furnace, which on account of the very high temperatures which can be obtained

*Louis A. Herdt, D.Sc., E.E., Professor of Electrical Engineering, McGill University.