HYDRAULIC POWER AND IRRIGATION IN FRANCE.

Up to the end of the last century small hydraulic plants and water mills, which were very numerous in France, employed only a small fraction of the total water power of the country. In 1890, according to the statistics of the department of agricultural hydraulics, these concerns numbered 69,620 for the whole of France, with a gross productivity of 1,028,807 horsepower, equivalent, because of the small yield of very imperfect appliances, to an effective horsepower of only one-third that amount. These matters were commented upon very fully by M. Reni Tavernier, Chief Engineer, Department of Public Works, France, in a report to the Geological Survey Department of the United States Government, from which the following discussion is taken:

The average productivity of each mill was 14 h.p. gross and 5 h.p. net. These small plants, when erected upon streams well supplied with water, generally used only a fractional part of the available power and water, and left the remainder available for other purposes, such as irrigation. But this is not the case with large modern power installations, where a single plant gathers up several thousand horsepower. In the region of the French Alps alone—which to be sure, is the best provided with hydraulic power—there are 90 plants producing a total maximum of 325,000 h.p., an average of 3,600 h.p. for each concern.

A feature of the progress made during ten years in the method of utilizing large waterpower plants is indicated by the large power-distributing enterprises. Such enterprises, employing the technical inventions that continue to extend the practical limits of long distance transmission, have sprung up in various parts of France in which water powers are located. The experience acquired in the past in the exploitation of railroads must be applied to the better organization of the public services for power distribution.

The new tendency is to build, at the very start, a series of canals that will divert the entire low-water flow of the streams. Many of the large plants are fitted up not only for operating with the minimum flow that can be counted on at all times of the year, but also for using the average flow such as may be reckoned on more or less irregularly during only eight, six, or even fewer months of the year.

Hydraulic plants do not actually use up the water itself, which is always available for application to the soil after it has passed through the wheels. They do not interfere with the use of the water for irrigation below the point of exit. They prevent its use above that point. They consume the fall necessary to carry the water to the fields lying at altitudes between the upper and lower levels of the power plant. Hence the erection of one of these "complete" or integral power plants amounts simply to appropriating the impetus of the stream, which also constitutes, so to speak, the "energy" necessary for watering the soils that might benefit by irrigation. It may be more profitable for all parties—as we shall attempt to show later—to resort to the system of storing up this "energy" rather than to that of storing up water taken at the upper level of the fall. But before considering this question we must clearly grasp the dissimilar economic characteristics of the various types of hydraulic plants—characteristics that depend upon such circumstances as the altitude of the fall, the volume of water and its fluctuations, whether the stream is tapped by a channel at a higher level or the water dammed at the point of use, and whether it is possible to accumulate the flow and to regulate the plant without loss of water but in accordance with the demands of its customers.

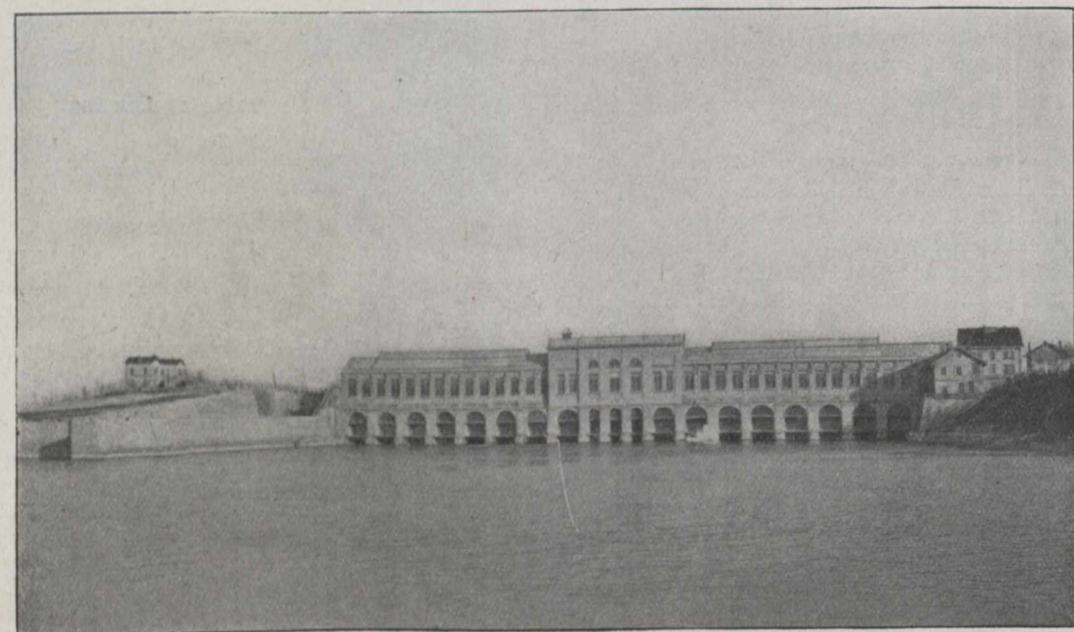

Fig. 1.—Lyons.—Generating Station on the Rhone.

In France the productivity in horsepower of a hydraulic plant is calculated by means of the following very simple formula: $P = H \times Q \times 10$, in which H is the height of the fall in meters and Q the discharge in cubic meters per second. This gives us the gross productivity in horsepower, each of 100 kilogram-meters *a* per second, which corresponds at the turbine axle—assuming a net yield of 75 per cent—to a horsepower of 75 kilogram-meters per second.

But the industrial value of a power plant is not measured solely by its power thus calculated. In the first place, the