remarkable in their wisdom, and the plant was successful from a technical stand-point from the start. The Niagara Falls development was completed in 1894, and power was transmitted to Buffalo in 1896.

The voltage used in this transmission, 11,000 volts, was not the highest voltage then in use, nor was the distance of transmission, some twenty miles, the longest, but the scheme was of the greatest importance on account of its magnitude and possibilities. In the larger cities the steam-driven plants, mostly single-phase, were still being built. In Colorado at Teluride, there was in operation previous to this a power plant and transmission line at a higher voltage and longer distance. Other schemes were started, and the development of huge central stations, driven by water-power or by steam, and distributing poly-phase electrical energy, has kept growing at a rapid rate ever since the Niagara Falls development.

Larger Systems Gradually Merge

In 1900 the large cities were using considerable quantities of electrical energy, but principally for lighting the streets and to a small extent for residential lighting. Electric tramways had been introduced some ten years before on a large scale, and large amounts of power were used for this purpose.

About this time, that is, in 1900, many schemes were initiated which, in the seventeen years which have passed since that time, have developed into the huge systems which now cover the principal parts of the United States with a network of transmission lines.

As these larger systems increase in size they approach one another, and sooner or later a physical connection will be made. Some arrangement of interchange of power will take place, and from the point of view of the distribution of electrical energy, the systems will become one. Thus we may look forward to a time in the near future when a network of lines will cover the thickly-settled parts of the United States, and will consist of a huge interconnected system.

Owing to the abnormal conditions arising from the war, four great companies in California have recently pooled their lines and generating stations, and by interconnection are striving to get the maximum benefit. These four companies control thousands of miles of lines, and supply the energy requirements over 40,000 square miles of territory.

Since about 1900 no very fundamental changes have occurred in the general scheme of power generation and distribution.

The greatest factor in the development of the steam-driven central station has been the growth of the steam-turbine. Steam turbines first made their appearance in this country on a commercial scale in 1899. Since that date the sizes have grown from 1,000 kilowatts to 50,000 kilowatts. The development of the steam turbine has placed the steam central station once more in the race. It has practically eliminated all talk of gas engines, and to-day with coal at peace prices, the large machine steam station favorably located, can produce power at ordinary load factors, more economically, everything considered, than most water-powers with their long transmission lines.

Growth of Transmission Systems

The most surprising thing has been the growth of the transmission system. A few figures will show this clearly. In 1900 the Shawinigan Water and Power Co. owned no system. In 1910 the total mileage of circuits of over 12,500 volts was 315 miles. In 1917 the total mileage was 1060 miles.

The Hydro-Electric Power Commission's system of the Province of Ontario, Canada, in 1900 did not exist. In 1917 it possessed over 1,000 miles of circuits.

The Southern Power Company's system started about 1910. At the present time this system has a total mileage of 1,500 miles.

If you plot a map of the system of electrical distribution "main lines," you will find that generally speaking this system corresponds with the water-power development. All along the eastern seaboard, rising in the Appalachian Mountains, rivers flow eastward to the sea, On account of the proximity of the mountains to the ocean, waterfalls are numerous in New England and in the South. In the middle West and North we find electric systems, principally in those sections traversed by rivers flowing into the Great Lakes. In the South, in the mountainous districts of Colorado and Utah, have arisen also water-power stations and electrical networks; finally, on the Pacific Coast, there has grown up one of the greatest groups of systems existing in the world, extending practically from the Mexican boundary to Canada.

As one examines the story of one of these systems, he finds something like this: A water-power was harnessed, and a transmission line built to some not far distant point. As the demand for power increased the voltage was increased, the lines lengthened, and the original water-power station enlarged so that gradually systems which were installed at various points finally met and merged into one.

We have to-day reached a point in the building of transmission lines when it seems clear that in many ways the story of the growth of the railroads is being duplicated. First, small branch lines were built; these were connected or joined together at some junction point, and trunk lines connected those junction points.

When alternating electric current systems started there were many frequencies. A frequency of 133 cycles was common, and then the frequency was gradually reduced year by year until the lowest frequency (25 cycles) used on any extended scale in this country, was reached.

Why the "Hydro" is 25 Cycles

At the present time it is fair to say that there are only two standard frequencies: 60 cycles, which is now generally recognized as the most important and the one which is adopted in probably 80% of the cases—the other 25 cycles, which was adopted as the frequency of the Niagara system, and in other cases where rotary converters were installed.

An interesting side-light is thrown on the choice of the 25-frequency by the story of the Niagara plant. The consulting engineers of that plant wanted 16 2-3 cycles chosen as the frequency, and the manufacturing companies manufacturing the apparatus wanted 33 1/3 cycles. Both sides presented claims of great merit; finally they compromised and made a choice at exactly half-way between the claims of the two parties interested, so 25 cycles became a national frequency, but not on its own merits, because it is generally recognized that the higher frequency of 33 1/3 or even 40 cycles would have been the wiser choice.

Thrust Bearings and Vertical Units

Turning to the water-power stations, we find that no standard system of apparatus had been evolved up to about 1905. At that time new types of thrust bearings commenced to appear, and the vertical water-wheel unit soon became the leading design. These units have now become so improved both as regards specific speed and efficiency that little more may be looked for.

Under favorable conditions, perhaps the years to come may bring plants surpassing the existing ones by 8% to 10% in over-all efficiency, but the real hope in water-power developments lies more on the financial side of the operation. Perhaps by more careful design, cheaper raw materials such as cement, and better and more economical financing, water-powers may be developed for less money per horse-power.

(Concluded in next week's issue)

The Admiralty Court recently reduced the bill of the Canadian Vickers, Limited, against the owners of the steamship "Susquehanna" from $53,983 to $35,000. The firm had contracted to convert the vessel for ocean traffic. No contract price was fixed, however, and the owners appealed against the amount for which they were billed.