principal materials used in the project, from which can be gained an idea of the size of the development:—

Excavation, 644,000 cu. yds.; dredging, 1,750,000 cu. yds.; gross floor area, 5,085,000 sq. ft.; concrete, 250,900 cu. yds.; reinforcing steel, 16,310 tons; concrete piles, 87,000 lin. ft.; wooden piles, 1,621,500 lin. ft.; timber, 3,000 M.b.m.; structural steel, 10,100 tons; steel sash, 261,300 sq. ft.; piping and conduit, 240 miles; paving, 61,000 sq. yds.; railroad trackage, 20 miles.

The general contract for the construction of the whole project was let to the Turner Construction Co., New York. A total of sixty-one sub-contracts have been let for the incidental work in connection with the project. The architect was Cass Gilbert, New York.

FACTORS RETARDING WATER-POWER DEVELOPMENT

And the Advantages Gained by Utilizing Available Water Resources—Efficiency of the Steam Turbine a Big Consideration

By D. H. Colcord
Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.

CERTAIN economic and legislative factors have taught the uninitiated investor in "hydro-electrics" several costly lessons in recent years, and it seems worth while to review these considerations:—

(1)—Load-factors have been overestimated.

(2)—Drought in summer and ice in winter have prevented the constant source of power counted upon to supply the consumer. The initial cost for building impounding dams to overcome this difficulty was so great that although companies might have succeeded in the long run, during their infancy they could not compete with steam power companies.

(3)—The high cost of transmission systems in a mountainous country has been prohibitive in some degree.

(4)—The cost of installation is high. In 1914, the total cost of installing hydro-electric plants was estimated at $27,000,000, including distribution systems and auxiliary equipment. This gives an average cost per horse-power of $158. A general estimate of the cost complete as given by a prominent engineering company, not including distribution or step-down transformers, has ranged from $75 to $150 per kilowatt installed. If the price of coal increases, in time it will compare favorably. At least the marginal difference in cost will demand increased efficiency in the operation of hydro-electric plants which might make up for this difference. The best steam practice secures at the electric generator less than 20 per cent. of the energy stored in coal, while the efficiency of the water wheel frequently exceeds 90 per cent., which is worth considering.

(5)—The rapid development of the steam turbine, with its increased efficiency, has discouraged water power.

(6)—Distance from the market has been a factor.

(7)—The high value of land in industrial districts has restricted development.

(8)—Railroads have followed the streams and in many instances would have to be rebuilt.

(9)—Many of the streams are of an interstate, interprovincial, or international character, involving legislative difficulties.

(10)—The fact that several projects have been started and abandoned has had a bad moral influence.

(11)—Long-term franchises held by municipal heating and lighting companies made competition impossible.

(12)—The forestry laws contain inadequate provisions for the leasing of land.

(13)—There is a scarcity of real good head sites.

(14)—There is not enough data available on the geological features of stream beds.

(15)—The recent scarcity and high cost of labor and building material has prevented, since the war, even the completion of developments already started.

The 1916 report of the Pennsylvania Water Commission contains data on hydro-electric projects that have been started and dropped for various reasons, as follows:—

(*a*)—Projects were begun at a time when there was a marked scarcity of capital.

(*b*)—The companies failed to realize the necessity for a complete engineering survey. Improper sites were chosen and then abandoned.

(*c*)—Hydrographic conditions were overestimated and in some cases there was not as much water available as counted upon.

(*d*)—Commercial surveys were not thorough in all cases and companies in some cases overestimated their markets for power.

(*e*)—In three instances uncertainty in regard to the legal rights possessed by the companies, and subsequent legislation, blocked their progress.

(*f*)—In several projects, the blame for failure can be laid at the door of financial misfortune.

The general advantages derived from water-power developments are:—

(1)—The highest use of coal is to create heat to preserve man's life and the term of man's existence may depend on the care of the supply. Fuel is not essentially reproductive. Water-power for industry can save millions of tons of coal a year.

(2)—The industrial section depends primarily on fuel and any effort to conserve fuel will lengthen productive life.

(3)—The electrification of all railroads is inevitable and provision must be made to supply the electric power. As railroads follow the streams, the natural source of power is that which is the most available—the stream itself.

(4)—Water power makes electric lighting possible wherever it is needed.

(5)—Where steam power is already used, it can well be supplemented by water power.

(6)—Storage reservoirs used with hydro-electric plants are a protection against floods.

(7)—During the droughts in summer, the expulsion of water from impounding dams improves sanitary conditions along the stream below.

(8)—Impounding dams on rivers often improve navigation.

(9)—Thickly settled districts afford a large market for electric power, with reasonable transmission distances.

(10)—Old canals and dam sites often make it possible to install a plant at small cost.

(11)—There are many limestone streams in mountainous districts that have a high rate of flow during the dry seasons.

(12)—Labor released by the winning of the war can be used to build the plants.

(13)—Increased industrial efficiency is effected, due to labor saving and waste prevention in distributing power.

From a conservative and absolutely safe standpoint, considering immediate returns on the investment, the correct policy is to use water power only to supplement steam where coal is available at a fair price. But this policy is somewhat pinched and near-sighted from national, industrial and economic standpoints, because the time is coming when the available coal will be gone. There may come a time when the coal that is left will be required for purposes that a central station cannot serve, such as driving the engines on our ocean liners, or as fuel for keeping us warm.

In Great Britain, proposals have been set forth for vast central station power plants, and stock is being taken of all of the water powers of the British Isles. Since the outbreak of the war, the Italian government has proceeded with an active water-power policy. In 1917 and 1918 there have been concessions granted for 1,024,000 horse-power. Norway has developed 1,120,000 turbine horse-power and plans to export hydro-electric power to Denmark. Barcelona, in Spain, is replacing steam power by hydro-electricity. In Switzerland, 25 per cent. of the 2,000,000 available horse-power has been developed. A Canadian company has completed a large portion of an extensive system of reservoirs and hydro-electric stations on the Nogurea Pallareasa and Segre Rivers. All this is indicative of the fact that people are laying a lasting foundation for power for years to come.