HISTORY, ELECTRICAL INSTALATIONS AND POWER USES OF CONOWINGO PROJECT

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With the exception of the St. Lawrence, the Susquehanna River basin is the largest and most important on the Atlantic Coast, and embraces a total area of 27,400 sq. miles, which comprises 47% of the total area of the State of Pennsylvania, 13% of the total area of the State of New York, and 2% of the total area of the State of Maryland.

The annual precipitation over this area, according to records of the United States Weather Bureau, varies from 31.4 inches to 44.3 inches, with a mean of 39.4 inches. The run off which eventually finds its way to the sea through the Susquehanna River, varies from 16.6 inches to 29.1 inches and averages 55% of the rainfall. The run off is at a minimum in August, September, and October, during which months it ranges from 5 to 30% of the rainfall and averages about 15%. Like all other Pennsylvania streams, the Susquehanna River has a natural run off extremely variable, both from day to day or week to week and from season to season.

High waters frequently occurs in January from melted snow. Floods accompanied by ice gorges occur usually in March and result in a high water level, although with lesser volume of flow than at times of clear water floods caused by heavy rainfalls, occurring over the whole or a portion of the water shed as late as June. In late summer or fall, periods of low water are frequently noted.

During the past century there have been several great

floods in this river, the most notable of which was that of June 1889, which was coincident with, although not caused by the Johnstown Flood, and which probably exceeded any flood that ever occurred in this stream. It is estimated that during this flood the flow reached a maximum of 730,000 cubic feet per second.

An official hydrograph of the Susquehanna River for years 1891 to 1925 shows that the minimum discharge at Harrisburg, Pa. was 2,200 cubic feet per second, this occurred in 1909.

The head waters of this river system are on the elevated plateau which separates the waters which flow south and east into the Atlantic streams from those flowing north and west into the Mississippi, St. Lawrence and Great Lakes.

The Susquehanna river has a fairly uniform grade of $2\frac{1}{2}$ feet per mile throughout its entire upper region. Below, or in the lower forty miles of its course the slope increases to an average of 5 feet per mile to tidewater and the width of the river becomes contracted, narrowing into a gorge, which in places is reduced to a width of two-tenths to one-half mile.

In the last 27 miles of its run the river drops from an elevation of 225 feet with an average slope of 5.6 feet per mile, causing a swift current, which has worn a low water channel of great depth in many places.

Along this lower section the river has cut its way through a range of tableland and its bed is walled by steep rocky bluffs on both sides, affording excellent foundation for water power development.

For more than forty years the possibilities of power de-

velopment in this lower course of the Susquehanna River have engaged the attention of engineers and capitalists. The first evidence of contemplated power development in this river is found in the act of Legislature of the State of Maryland which was passed in 1884 authorizing the Susquehanna Water Power and Paper Company of Harford County to acquire certain property, by condemnation, necessary for the proper extension and development of its existing dam or any dam it might locate or build near that site.

This water development consisted of a small wing dam in the bed of the river an intake channel, head gate, power plant and tail race. Part of this work is still in existence and comprises what might be termed the first water power development of the Susquehanna River.

Until, however, the growth of the steam generated electric systems in nearby cities had developed a market capable of absorbing a large part of the energy in the flow of this river its power development was not economically feasible.

However, in 1910 the Pennsylvania Water and Power Company completed a dam and power house at Holtwood, Pennsylvania, which now has an installed capacity of 150,000 horse power.

The Philadelphia Electric Company, through its subsidiary, Philadelphia Electric Power Company and the latter's Maryland subsidiary, The Susquehanna Power Company, obtained a Federal License, which was approved February 20, 1926, to build a dam and power house at Conowingo, Md.

The dam and power house will be located in Maryland, but

the upper half of the reservoir and the greater portion of the transmission lines will be in Pennsylvania. This required joint action by the Public Service Commissions of the two states. Also, as the War Department has ruled that the Susquehanna is a navigable river, a license from the Federal Power Commission was required.

The reason for the dam being in Maryland was to be able to produce the required maximum head.

By agreement with the Pennsylvania Water and Power Company, a pool elevation for the Conowingo Dam of 108.5 feet above mean sea level, has been adopted. At this elevation the water will be backed up over a portion of the Holtwood Plant's tail race, which has not yet been excavated but which when excavated, will result in development of increased head and power at the Holtwood Plant. It was mutually agreed that this additional head could be developed more economically at Conowingo, and it therefore has been arranged, subject to approval by commissions having jurisdiction, that the Conowingo pool be maintained at elevation 108.5, the Holtwood Company to share in Conowingo's Plant's gain accruing from the increased head.

With the pool elevation decided upon, it was desirable, in order to develop the maximum head, to locate the dam as close to tidewater as possible. Here, the Columbia and Port Deposit Branch of the Pennsylvania Railroad Company, located on the east bank of the river, imposed a limitation, in that it was necessary

to provide a satisfactory grade from the present road bed to the north end of Port Deposit to the elevation of the relocated tracks above the Conowingo Dam. A grade of .35% was finally accepted by the Railroad Company.

Five possible sites for the Conowingo Dam were examined and an exhaustive study made of the head and power available and the total cost of development at each. The site as finally adopted is located approximately two miles below the village of Conowingo, Maryland, and is far enough north of Port Deposit to permit the use of the accepted maximum run off grade of the railroad. A reservoir having an area of approximately 14 square miles will be formed.

The hills on either side of the river at this location form natural abutments, that on the Cecil County or east side rising to an elevation of 250 feet above sea level, and on the Harford County or west side rising to an elevation of 155 feet.

The river bed and banks to a height well above the pond level, are of granitic formation. During the Autumn of 1924 twenty six core borings were made along the line of the up-stream face of the dam, between the two abutments. These were drilled to depths varying from 5 feet to 30 feet below the rock ledge. All these cores showed firm hard granite or gabbro. In additional to these, four borings were made to a depth of 100 feet below the rock ledge, and these also showed hard rock for their entire length.

On the east bank then is ample space for the erection of construction camp and plant and for storage of materials. Transportation facilities are supplied by the Columbia and Port Deposit Railroad.

The main channel of the river at this site is along the west bank. The power house therefore is being built at this end of the dam. Space for construction plant on this side of the river is somewhat limited, but an old canal which formerly operated on this bank has been partially filled in to provide space. To supply transportation facilities for the power house construction it was necessary to construct approximately 10 miles of railroad to connect with the Pennsylvania Railroad System at Havre de Grace. The tow path of the old Tidewater Canal afforded an excellent road bed, requiring very little grading, and within three months of the start of construction work this railroad was in operation.

Early in March, 1926 the construction of the Conowingo Dam and Power House was started, with an initial wheel capacity of 378,000 h. p. (594,000 h. p. ultimate capacity). As the Philadelphia Electric Company will use practically the entire output of the Conowingo Project, it was necessary that it should control the operation of the plant. It was also essential, in order to make the securities of the project attractive to the investing public, that the Philadelphia Electric Company should guarantee the completion of the project and be responsible for the payment upon which the securities of the project depend for support. As

the Philadelphia Electric Company is not allowed by its charter to do business in Maryland, these requirements were met by arranging to have three subsidiary corporations as follows:
First, the Susquehanna Power Company, incorporated in Maryland, will own all physical property of the project located in that state, comprising the dam, power house and tail race, and portions of the reservoir and transmission lines.
Second, the Philadelphia Electric Power Company, incorporated in Pennsylvania, will own all physical property located in Pennsylvania, this being principally lands for the reservoir, and also the greater portion of the transmission lines. This company also owns all of the stock of the Susquehanna Power Company.

The voting stock of Philadelphia Electric Power Company is all owned by the Philadelphia Electric Company, which also leases the transmission lines owned by Philadelphia Electric Company.
And third, the Susquehanna Electric Company which was formed for the purpose of leasing for the term of license, the properties of The Susquehanna Power Company in Maryland, under contract with the Philadelphia Electric Company, will operate the plant and will sell all energy generated to The Philadelphia Electric Company. All stock of The Susquehanna Electric Company is owned by The Philadelphia Electric Company.

As set up, therefore, the Conowingo Hydro Electric Development is being made by and for The Philadelphia Electric Company and when completed, will be operated as a part of that Company's system. The construction of the development is in

charge of the Engineering Department of The Philadelphia Electric Company.

Contract for the design and construction of the dam and and power house has been awarded to Stone & Webster, Inc., who have subcontracted the construction of the greater portion of the dam to The Arundel Corporation of Baltimore. The Arundel Corporation has been awarded also the contract for relocation of the tracks of the Columbia&Port Deposit Branch of the Pennsylvania Railroad. Contract for the design and construction of the transmission lines, and for the switching station located on roof of the power house has been awarded to Day & Zimmermann, Inc.

The west abutment of the dam is in a projecting hill or rock, into which a retaining wall section, extending 145 feet from the power house to the abutment, will be built to form an adequate seal for the impounded waters. The head works for the power house providing for eleven main units and two station service units, then extend 900 feet to the beginning of the spillway section which is 2385 feet long. From the east end of the spillway the retaining wall section continues 1200 feet to the east abutment, which also serves as the abutment for the highway bridge over the relocated tracks of the Columbia and Port Deposit Railroad.

The dam is solid masonry construction of gravity type, founded on rock at an average elevation fifteen feet above sea level. The spillway section is designed to take care of floods up to 880,000 cubic feet per second. It has fifty movable crest gates for the purpose of regulating the level of the storage

reservoir. They are 22½ feet high by 40 feet long and weigh about 42 tons each.

The power house, as noted above, is located adjacent to the west shore. The head works provide intakes for the eleven main units and two service units. By locating the top of the intake openings 40 feet below the pool level, protection from floating ice has been secured without expense of constructing the usual rock fill and skimmer arch to protect the forebay.

The superstructure of the power house will be concrete, with a structural steel frame. The high-tension switching station will be located on the roof.

Seven main water wheel units will be installed at this time, four will come from the Allis-Chalmers Manufacturing Company and three from the Wm. Cramp & Sons Ship & Engine Building Company. Each unit will have a capacity of 54,000 h. p., and will be the vertical shaft, single runner, Francis reaction type.

The two station service water wheel units, supplied by the S. Morgan Smith Company, will be 1900 h. p. each and of the same type as the main water wheel units.

Seven main generators and two station service generators will be installed; four main generators to be provided by the General Electric Company and three main generators and the station service generators by the Westinghouse Electric and Manufacturing Company.

Each main generator will have a capacity of 40,000 kva., generating at 13,800 volts, 3 phase, 60 cycle, will be direct con-

nected to a main water wheel unit and will be provided with direct connected 715 kva. auxiliary a.c. generator.

Each station service generator will have a capacity of 1600 kva., generating at 460 volts, 3 phase, 60 cycles, will be direct connected to one of the station service water wheel units, and will be provided with a direct connected d.c. exciter.

Stationary power transformers will consist of four banks of three transformers each having the following rating: 26,667 kva., rated capacity, 29,333 kva., overload rating, single phase, water cooled, 13,800 low tension voltage and 127,000-222,000 volts Y at the high voltage terminals. The guaranteed efficiency at rated capacity is in excess of 99%.

The energy generated in this plant will be transmitted to Philadelphia at 220,000 volts to be utilized in The Philadelphia Electric Company System.

In the average year it is expected that the seven units of the initial installation will generate 1,380,000,000 kilowatt hours.

When the Pennsylvania Railroad is electrified between Philadelphia and Washington, they will receive all of their power from the Plant at Conowingo.

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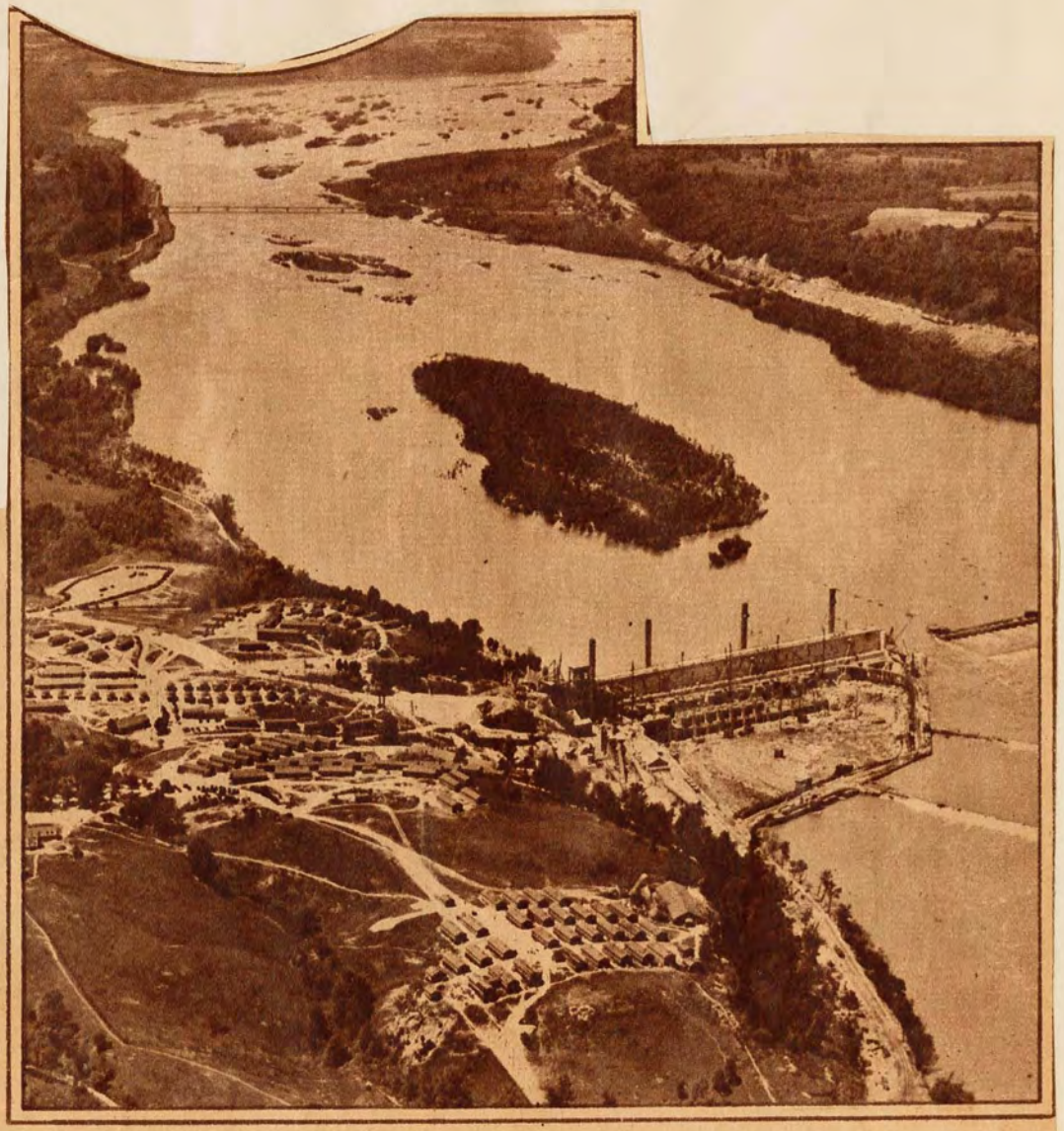
Present Progress on the $52,500,000 Conowingo Power Project as Viewed From the Air

LOOKING ACROSS THE GREAT DAM FROM THE WEST BANK OF THE SUSQUE

In the foreground is the construction city, which has sprung up like a mushroom since the start of the work ago. The huge power plant will rise in the triangle at the western end of the dam. The cleared track ex picture is the route of the sixty-five-mile transmission line to Philadelphia. The winding white road is the E run over the completed dam, shortening the auto route to Washington by four and a half miles. The white l marks the relocation of the Columbia and Port Deposit Railway, which is being moved back for a di



WHERE A MIGHTY LAKE WILL BE FORMED

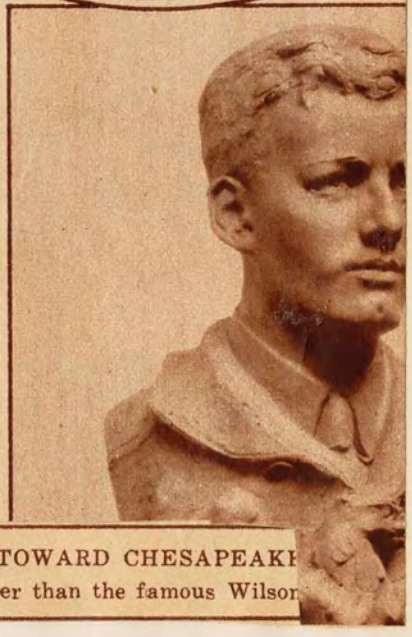
Paper Mill Island, just above the dam, will be entirely submerged. Across the narrows is the Conowingo Bridge, which will be abandoned when the Baltimore Pike is carried over the twenty-foot roadway atop the dam. The work will be inspected next Friday by the Governors of Pennsylvania and Maryland and a distinguished company

Photos (c) Victor Dallin

"WE" MEET THE KING OF THE BELGIANS

Captain Lindbergh explaining the mechanism of his plane to King Albert at the Evere aerodrome, Brussels

(c) P. & A.



COLONEL LINDBERGH MODELED IN CLAY

A striking bust of the youthful air

A VIEW DOWN THE RIVER TOWARD CHESAPEAKE

The dam is 4633 feet long, or 300 feet longer than the famous Wilson Shoals. In the dis-

THE UPPER END OF THE FOURTEEN-MILE BASIN

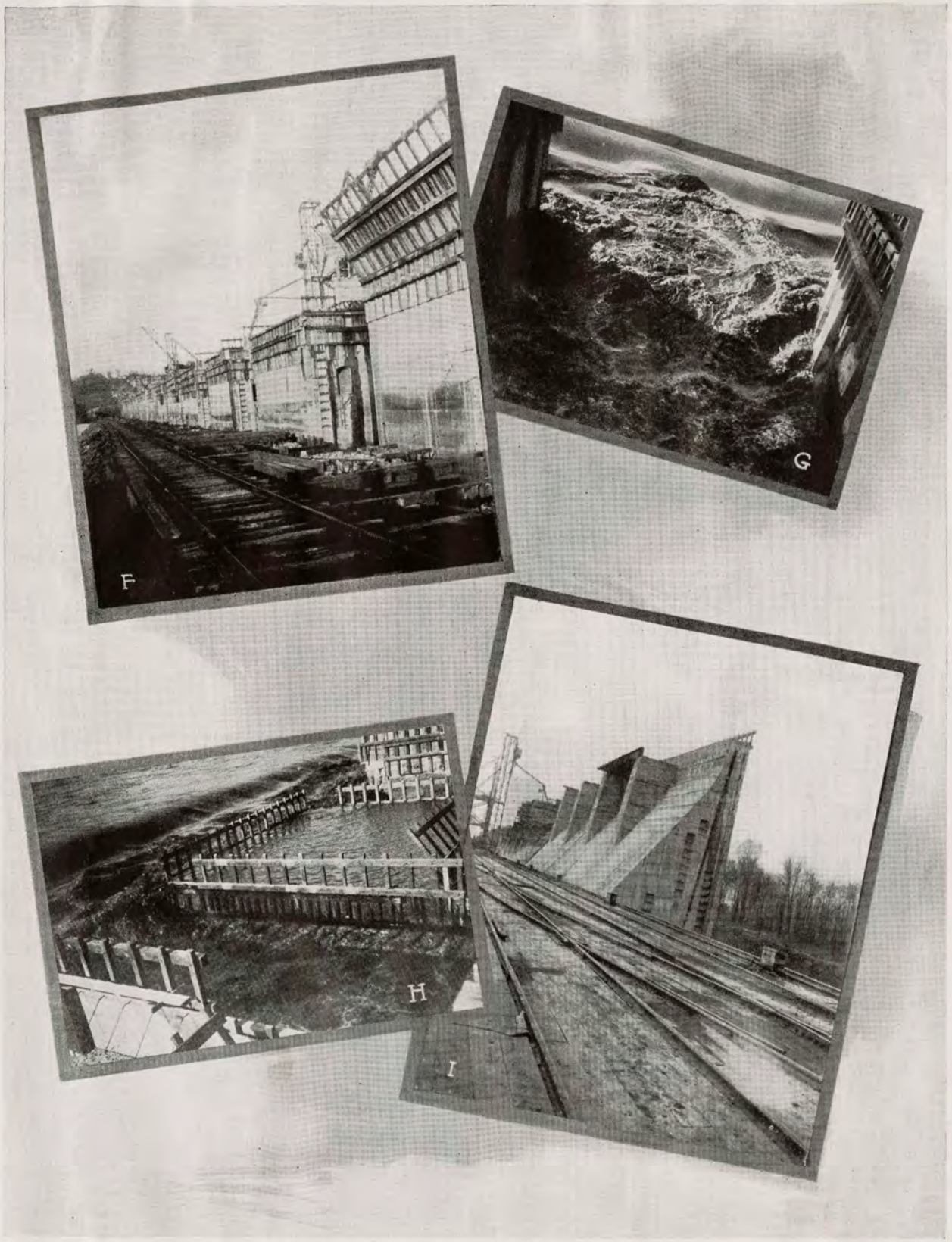
The 9000-acre lake formed by the completion of the dam late this summer will extend almost up to the Holtwood dam and power plant (shown in center of picture), which supply Baltimore with power. The capacity of the basin will be 14,000,000,000 gallons

Fig. 9—East Plant, general view showing progress of construction on dam.

Fig. 10—East Plant, showing construction-bridge, deck, gantry crane and concrete mixing plant.

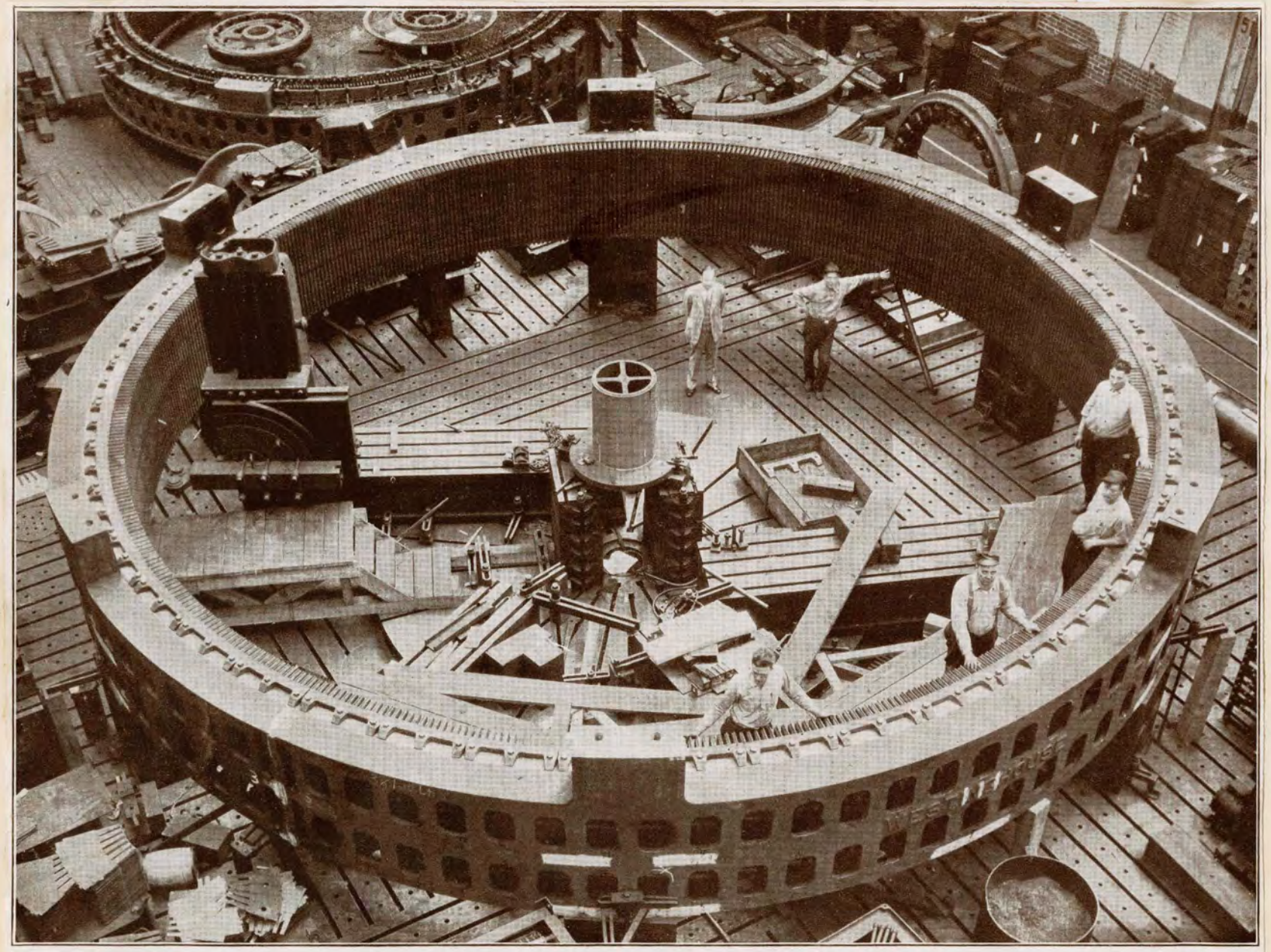
Fig. 1. Map Showing Susquehanna River Basin.

A—West Plant—Looking upstream from towpath showing west abutment, west of first service unit, and retaining wall. B—West Plant—Looking north-northeast from west abutment at night, showing work in power house cofferdam. C—East Plant—Looking south-southwest along downstream side of construction trestle during flood. Cofferdam under about 9 feet of water. D—West Plant—Looking north-northeast from west abutment showing progress in power house cofferdam and concrete at west abutment. E—East Plant—Looking south from Penna. Railroad showing progress on dam. Contraction joint of abutment section is at station 34 50.



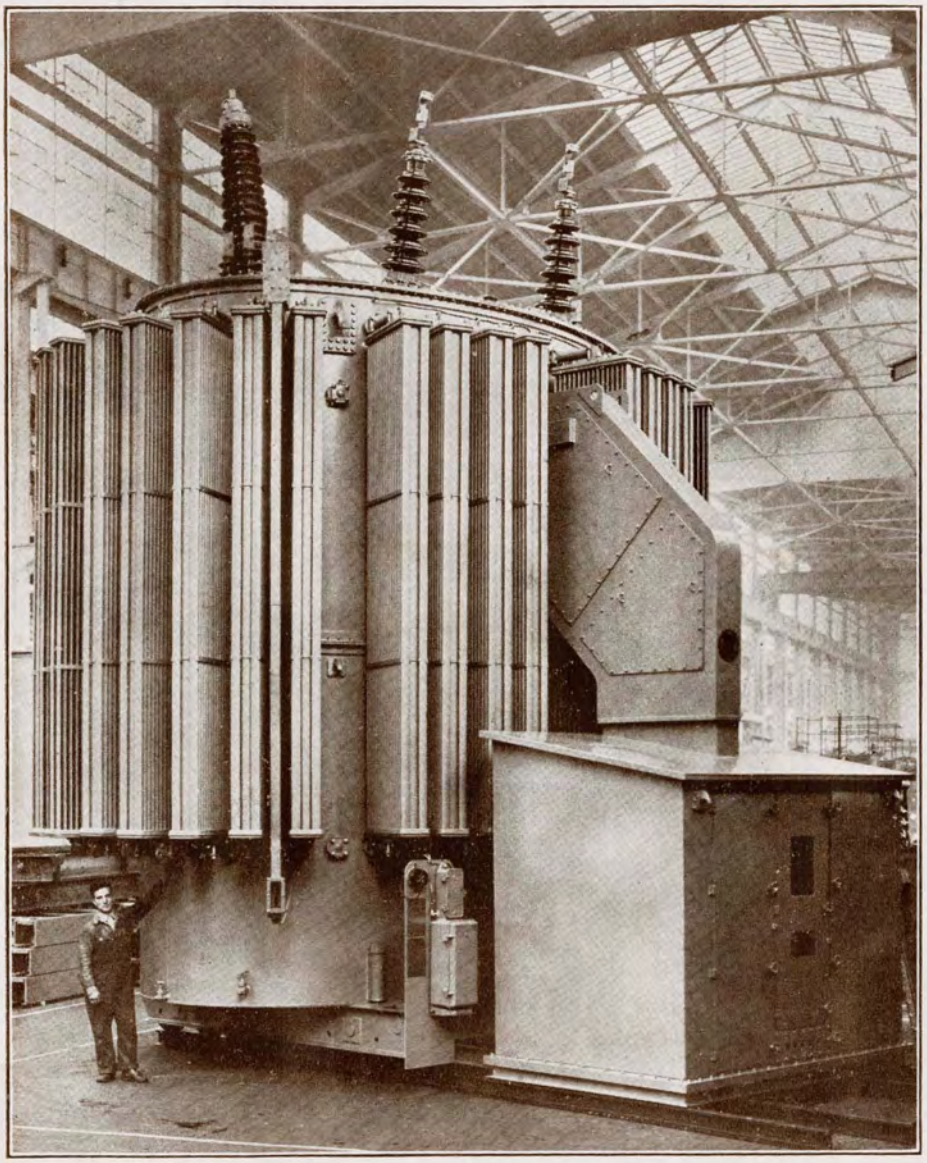
F—East Plant—Looking northeast from end of upstream cofferdam showing progress on spillway section. G—East Plant—Looking west-northwest from construction trestle showing water running through 38-foot opening in spillway section during flood. H—East Plant—Looking north-northwest from construction trestle showing water running over cofferdam and through 38-foot opening in spillway section. I—East Plant—Looking southwest from construction trestle showing abutment section of dam raised to 112.71 feet. Four piers raised to final height, 108.5 feet. One 48" highway girder in place. Contraction joint is shown at station 34 50.

Fig. 3. United States Geological Survey Map, showing the territory in which the Conowingo Project is located, and the relative positions of Holtwood and Conowingo Dam.



The frame of one of the Westinghouse waterwheel generators for the Conowingo development as it lay on the floor of the Westinghouse Works at East Pittsburgh. This frame is 38 feet in diameter and it is not exceeded in size by any other machine except the large steam engine driven generators built by Westinghouse two decades ago.

TRANSFORMERS



One of the seven self-cooled transformers built by Westinghouse for the Plymouth Meeting Station of the Philadelphia Electric Company near Philadelphia, U. S. A. These transformers are the largest single-phase transformers in the world. They are rated at 33,333 kv-a.

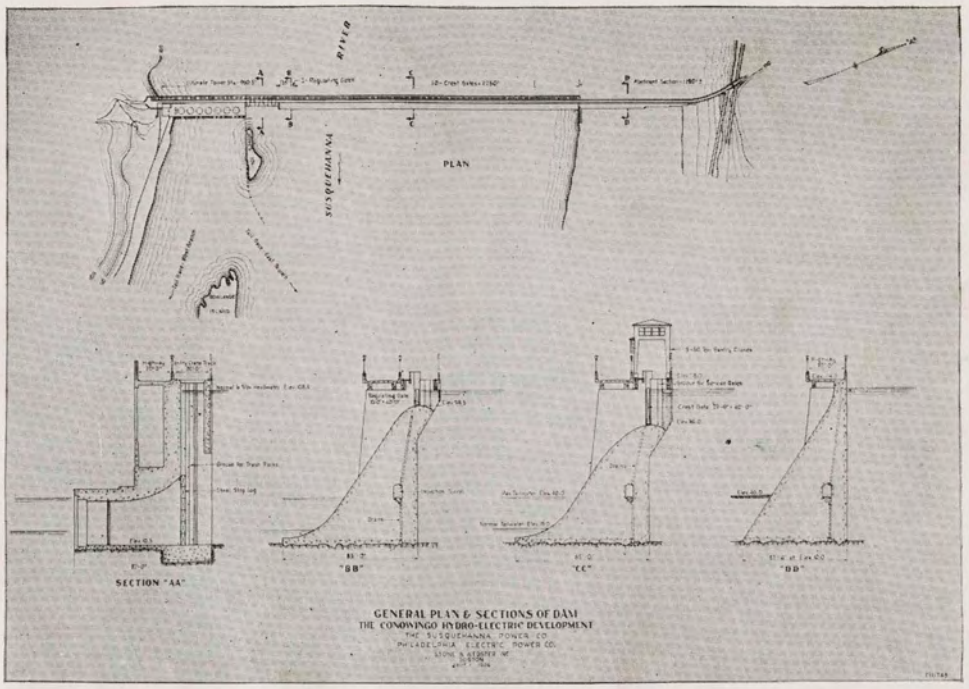


Fig. 4—Showing general plan and sections of dam.

Construction Camp on West bank.

View of Switching Station on top of Power House

Power House and Switching Station

Crane used to raise Crest Gates

View of Dam from West Bank