A HYDRO-ELECTRIC PLANT THAT PUMPS ITS OWN WATER SUPPLY*

THE ROCKY RIVER HYDRO-ELECTRIC PLANT.

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The statement that a hydro-electric plant can pump its own water supply sounds absurd on the face of it, yet this is virtually what happens in the case of the Rocky River Hydro Plant just being completed by The U. G. I. Contracting Company for the Connecticut Light and Power Company at New Milford, Connecticut.

This is the first hydro-electric plant in America which involves the pumping of the major portion of the water used to produce electric energy. It takes 1.63 times as much energy to raise the water into the reservoir as is obtained from the same water when it flows back to generate electric power. The condition which makes the project economically sound and not a senseless dream is the fact that the stored water is used at seasons of the year and hours of the day when it has a high value, while the energy used for the pumping is obtained at times of the year and in the night hours from water that would otherwise spill over the dams or from steam plants that have to be kept in service anyway. Expressed differently, the pumping is done with low-cost off-peak energy while the energy from the stored water can be released at peak-load periods when it has a high value.

Economics of Pumped Storage.

There are no new economic principles involved in pumping plants for storage. Careful consideration of all the factors and costs are required as in the case of any other hydro project. The storage reservoir on a tributary stream performs the same functions as would a reservoir on the main river. These functions are primarily regulation of the river by storing from wet to dry

* Presented at Forty-fourth Annual Meeting, New Haven, February 22, 1928.

months and the daily or weekly pondage of water to permit the installation of greater plant capacity for peak loads. If nature had placed the Housatonic River bed two hundred feet higher above New Milford and then let it drop off quickly in a natural fall we most certainly would have placed the dam across the Housatonic and not across the Rocky River. The natural fall was not there and we had to create one. The Rocky River basin of wild, largely unsettled, almost virgin territory furnished a feasible location for a large storage reservoir.

Status of Pumped Storage Plants in Europe.

A search of engineering literature for data on hydro plants using pumped storage was made in our office and it was found that 41 such plants have been built or are being built in Europe. Several have been thought of in America but the Rocky River plant is the first large one to be constructed. The European plants vary greatly in size, the smallest having a pump rated at 190 h. p. and the largest, at Hengstey, Germany, having 32,500 h. p. pumps. The majority of the European plants use day-to-day pondage and not seasonal storage.

General Features of Project.

The essential features of the Rocky River Development are as follows:

A Reservoir with an area of 8.3 square miles. This will form the largest lake in Connecticut and will extend from above New Milford nearly to Danbury;

Small Dikes at low places in the hills surrounding the reservoir;

An Earth Dam, 100 feet high, 952 feet long and 525 feet wide at the base at the maximum section. 350,000 cubic yards of earth were required to build this dam. The material consists of a dense mixture of rock flour, sand, small stones and boulders. This gives a material well suited to earth dam construction as it produces a dam both stable and relatively impervious. The rock flour is a material approaching the fineness of clay but without the colloidal properties of clay which are objectionable for an earth dam built by the hydraulic or semi-hydraulic fill methods;

An Intake Canal and Dike about ½ mile long. The material for the dam was excavated from the canal, thus killing two birds with one stone. The dike beside the canal is also built of material excavated from the canal. The dike is in reality a continuation of the earth dam;

An Intake Structure with trash racks and an emergency gate for shutting off the flow of water into the penstock;

A Wood Stave Pipe Line; a *Steel Surge Tank* at the top of the hill above the powerhouse; a *Steel Penstock* down the hill to the powerhouse.

The Powerhouse containing the turbines and pumps. The powerhouse is on the bank of the Housatonic River but obtains its water from the storage reservoir in the Rocky River basin;

Highway Relocations and the *Relocation of Several Cemeteries.*

The major construction items are:

TABLE I.

SUMMARY OF MAJOR QUANTITIES.
(Exclusive of Highway Relocation)

Earth Embankments:	
Main Dam and Dike	690,000 cu. yds.
Small Dikes	50,000 cu. yds.
Concrete Placed	12,000 cu. yds.
Reinforcing Steel Required	400 Tons
Structural Steel Required	300 Tons
Lumber for Corewalls (Main Dam & Dike)	600,000 F.B.M.
Lumber for Wood Stave Pipe	200,000 F.B.M.
Steel for Surge Tank	100 Tons
Steel for Penstock	500 Tons

A detailed description will now be given of the design features of the various parts of the project.

THE RESERVOIR.

The reservoir has a surface area of 8.3 square miles, contains 6 billion cubic feet, 45 billion gallons, 138,000 acre feet of effective storage. The clearing of this reservoir was in itself an immense item. All brush and trees in the basin below the flow line were cut and burned. Some of the trees were cut and sold as railroad ties. The total salvage on the clearing, however, was insignificant. This reservoir would run the turbine at full load for 8 hours a day for about 4½ months.

MAIN DAM AND DIKE.

As previously stated the dam is 100 feet high, 952 feet long. A total of 690,000 cubic yards of material were required for the dam and the dike, 350,000 for the dam and 340,000 for the dike. The dam was built by hydraulic sluicing, by what is known as the full hydraulic method, that is to say, only water was used to transport the earth, not dump cars or trucks. (See Figure 1 for Cross Section of Dam.) A large part of the material in the dike was also placed by this method. The remainder of the dike

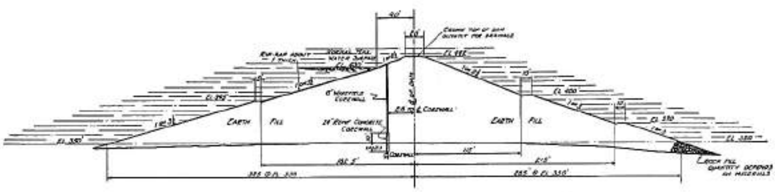

FIG. 1. Maximum Cross Section of Rocky River Dam.

material was placed directly in final position by the big drag line, care being taken to compact the material with water.

A noteworthy feature of the dam and dike is the use of wood for the corewall. A wood corewall is more flexible than one of concrete and the cost is very much less. The corewall is of the Wakefield type, made up ahead of time in units like Wakefield sheet piling, and bolted into position in advance of the sluicing operations.

The corewall is not entirely of wood, the base and the portion extending into the ground being of concrete. See Fig. 2.

INTAKE STRUCTURE.

At the lower end of the canal is a circular intake structure of reinforced concrete. This contains the trash racks and an emergency head gate to shut off the flow of water from the penstock. The head gate is a Broome Caterpillar type gate, 18½′ wide x 18′ high, manufactured by Philips and Davies. Normally it is electrically operated by a push-button control located at the intake itself, but can be lowered by a push-button in powerhouse in event of emergency. The circular type of intake (Fig. 3) was adopted after investigation showed that other types would have been too expensive because of larger amount of concrete required. The circular type also provides advantageous hydraulic features.

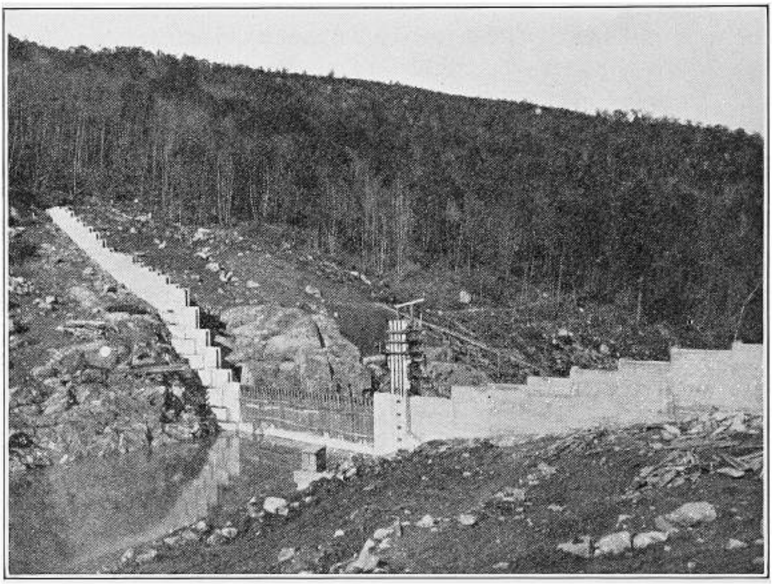

Fig. 2. Dam at early stage showing Concrete Corewall.

A 16-foot diameter reinforced concrete conduit 240 feet long leads from the intake structure underneath the end of the earth dike to the wood stave pipe line, which is in the open.

Wood Stave Pipe Line.

A 15′ inside diameter wood stave line carries the water from the dam along the side hill to a point where the line must plunge down to the powerhouse. The maximum static head on the wood line is 55 feet. The largest other wood stave pipe of which the writer knows is 16 feet in diameter and is located on the Pacific Coast. Low cost and protection from freezing determined the selection of wood stave pipe for this portion of the pipe line. The pipe is entirely above ground (Fig. 4).

Surge Tank.

At the end of the wood stave line the penstock must pass down a steep hill to the powerhouse and at this point a steel surge tank is placed, to take care of sudden load changes at the plant. The surge tank is 76 feet high, 28 feet in diameter, of the Johnson Differential type with a 9 foot diameter internal riser. It is not covered with lagging, but is to be kept free from freezing by a stream of compressed air.

Steel Penstock.

Between the surge tank and the powerhouse the penstock is of steel, varying in diameter from 13 feet to 11 feet. The one single penstock is used both for supplying the turbine with water and for filling the reservoir. (Fig. 5.)

Powerhouse and Machinery.

The essential data regarding installation and equipment are given in Table II.

TABLE II.

Hydraulic and Electrical Data.

Number of Hydro-Electric Generating Units (Present)....	One
Horse Power of Turbine..............................	36,000
Capacity of Generating Unit..........................	30,000 K.V.A.
Number of Pumping Units.............................	Two
Capacity of Each Pump (250 c.f.s.)....................	112,500 G.P.M.
Horse Power of Each Pump...........................	8,100
Elevation of Headwater (Maximum)	430
Elevation of Headwater (Minimum)	400
Elevation of Tailwater (Average)	200
Gross Head..	230 Feet
Average Net Head (for Power)	214 Feet
Specified Head for Pumps..............................	240 Feet
Average Pumping Head.................................	220 Feet

Figure 6 shows the general layout of the powerhouse. The large unit is the turbine and smaller units are the two pumps. The interesting thing to note is the similarity between the pumping unit and the hydro-electric generating unit, in fact it is well nigh impossible for one unfamiliar with the details to tell from the outward appearance or the general drawings of the pumping unit that it is not just an ordinary turbine and generator. The pumps and motors are set below the main generator room and covered with heavy removable floor panels, thus permitting the use of all

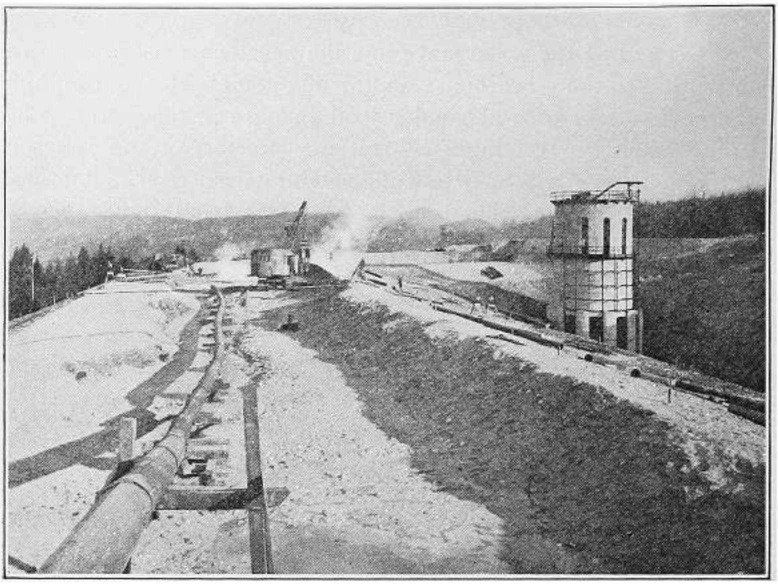

FIG. 3. Intake Structure.

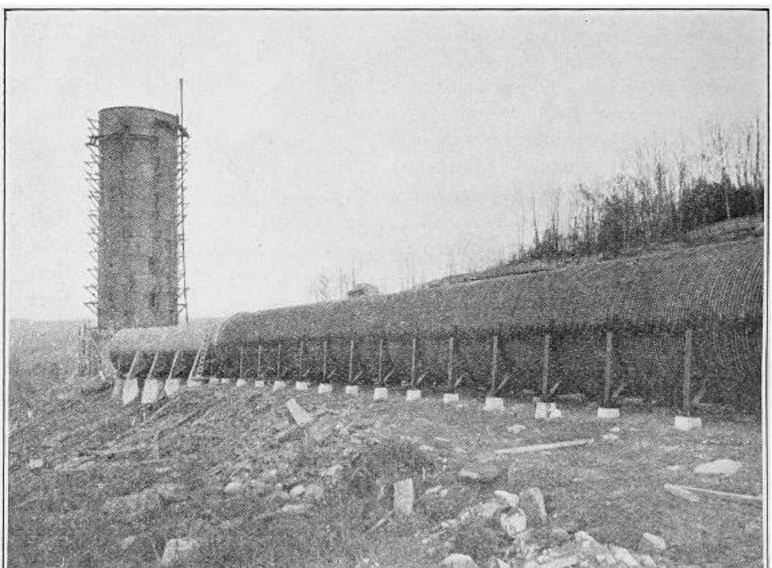

FIG. 4. Wood Stave Pipe Line and Surge Tank.