

View Looking Upstream at Dam on Island and across Main River Channel.

RAPID CONSTRUCTION OF AN INDUSTRIAL PLANT.

THE METHODS FOLLOWED AT THE ST. CROIX PAPER COMPANY'S WORKS, SPRAGUES FALLS.

Last February the St. Croix Paper Co. decided to build a pulp and paper mill at Spragues Falls, Me. The project had been talked over in a general way by the company and its engineer, Mr. George F. Hardy, of New York, but no working plans had been prepared when the decision to build was suddenly reached. About the time Mr. Hardy's engineering staff began work on the detail drawings a contract was let to Mr. Frank B. Gilbreth for the construction of the plant and a considerable portion of the mill village which had to be built for the employees. This contract affords an instructive example of the advantages of the cost-plus-fixed-sum method of executing work, the plans not being far enough advanced to receive lump sum bids. The company wanted a concrete dam 2,000 ft. long, a 75-ton ground pulp mill, 70-ton sulphite mill, 75-ton two-machine news paper mill, with all the accessories for such a plant, including a town with macadamized streets and houses for 2,500 people. To wait until the plans could be prepared in sufficient detail for bidders would entail a serious loss of time, and probably make it impossible to get the buildings closed in before winter, which was very desirable. The owners wished to have the plant in operation quickly, and this aim could best be attained by avoiding outdoor work in Northern New England in winter, although the installation of machinery indoors could proceed then without difficulty. Under such circumstances it is manifest that the award of a contract on the cost-plus-fixed-sum basis offers exceptional advantages in the way of hastening construction.

The site of this mill is at a point where originally there was a fall in the river of about 16 ft., which has been increased by the dam to 45 ft. The company is associated with others in a corporation practically controlling the entire stream, which has been dammed at a number of places in order that its flow can be regulated. The works at Spragues Falls start on the Canadian shore in a concrete dam about 25 ft. in maximum height and 550 ft. long, which runs across the main channel of the stream to an island. Here it makes a turn of nearly ninety degrees, as shown in the illustration above, and runs downstream over it for a distance of about 250 ft. to another turn of over ninety degrees. Near this bend is a log sluice and beyond it are the buildings of the plant, their upstream foundation walls serving also for the dam which runs to the American shore. These buildings are the grinding room and electric plant at the head of the tailrace, where the turbines are located,

and then in order, the wood preparing and wet machine room, blowpits, digesters and acid plant; the heater room, boiler house, machine room and finishing room are located back of the sulphite pulp plant, away from the dam.

When the contractor and his staff reached the site of the plant about ten months ago, the ground was covered with about eight or nine feet of snow. After examining the locality so as to determine the general arrangement of their plant, work was at once started on the construction of a camp. Contracts of this character differ very much from a railroad contract, for example, on account of the great variety of work done. This causes complication because the bricklayers, masons and other groups of workmen, down to the Italian shovellers, must be quartered separately if the greatest efficiency is to be attained. The buildings first put up were necessarily built on the snow, and as this melted they were blocked up until it was possible to lower them safely to the ground. The spur track from the railroad was also laid on the snow, and as the latter melted it was allowed to settle with the snow, without interrupting its use. While this work on the camp was in progress, the contractor was also engaged in perfecting the details of his organization. All these arrangements were indicated by a chart, which showed the relations of every man on the work to the others and to the central office. The position of the superintendent, clerk, timekeeper, superintending mason, superintending carpenter, foremen and workmen are all shown by a diagram, arranged on the same plan as a genealogical tree. These charts were posted in conspicuous places so that an employee on any part of the work could see his position in the general organization and the relative rank of those over him.

Work was started in April in the tailrace, where a considerable amount of rock excavation could be done advantageously, not only for the purpose of deepening the channel, but also to furnish stone for the large amount of concrete used on the work. Much of this concrete was made with large rubble stone embedded in the concrete after being carefully cleaned and washed. In order to carry on the tailrace excavation, and protect the site of the buildings an old crib-dam was built to guide logs away from the channel was reconstructed and enlarged. The new parts and a bulkhead running downstream on the river side of the tailrace were built by lumbermen, experts in this kind of work, and were floated into place and sunk with rock excavated from the tailrace. A great deal of blasting was done on the excavation and part of it was near one of the boiler houses supplying steam for various construction purposes. This house was accordingly built of logs, so that when it was struck by pieces of rock, sometimes weighing as much as a hundred pounds, they would be thrown off by the spring of the heavy timbers.

The natural lay of the land was utilized as much as possible in starting the work. The island was bare and the work on it could be carried on without serious trouble from the outset. From the island to the American shore, the early construction of the coffer dam enabled the construction to be pushed rapidly and without other interruption than necessarily attends the execution of work in a remote locality and subject to delays while the owners decide details which must be settled before all the working plans can be drawn. The main dam from the island to the Canadian shore was at first designed as a timber structure and materials for its construction were being assembled when the owners determined to make it a concrete dam. This made it necessary to secure additional concrete plant and to otherwise change the working scheme, so that this part of the work is not yet complete, although nearly so. One of the accompanying views shows the line of this dam from the island to the Canadian shore, and indicates the considerable amount of work done in the Dominion. This was started early and was attended with some inconvenience on account of the international custom-house requirements. At first men and materials were transferred across the channel by a ropeway, but later cribs were sunk in the channel and connected by timbers so as to carry a roadway. The cribs were used later as part of the upstream coffer-dam for protecting the main dam. Some of the materials used on the Canadian side were bought there, and those handled over from the American side were reported every night to the Canadian customs authorities. A stable had to be built for the horses because there is a Canadian law forbidding feeding and bedding horses used on American territory.

One of the concrete plants had a drum mixer located on the island near the angle where the main dam bends to cross over to Canada. There was also a batch mixer located on the island some distance upstream from the dam, at a place from which the material could be delivered readily to various parts of the work. The large plant shown in the views of the dam had an automatic measure and feeder designed by Mr. Gilbreth several years ago, and used by him on a number of undertakings.

The broken stone was crushed near the mixer, screened and delivered into the hopper bins, from which it was run into derrick boxes and hoisted to the platform of the concrete plant as required. Sand was delivered from the American side by a gravity railway several hundred feet long. The concrete was wheeled from the mixers in two-wheeled carts holding about 9 cu. ft. each, and the trestle platforms shown in the pictures illustrate the facilities for this part of the work.

The concrete for the main dam was mixed in the proportions of one part of Iron Chd Portland cement, three parts of sand and five parts of broken stone. It was very wet and no tamping was done except close to the forms. Large blocks of stone were placed in it after being cleaned, which resulted in a considerable reduction in the cost of the concrete in this case. The total cost of about 6,000 cu. yd. including the expense of crushing the rock, the materials and labor in building the forms of tongue-and-groove

plank, and the cost of all other items properly charged to this part of the work, was about \$1.20 a yard.

The dam across to the American shore was built in alternate sections, with dovetails on the ends so that when the intermediate sections were built the whole structure was locked together into a single unit. The main dam across to the Canadian shore was started behind coffer-dams

Mr. Gilbreth, partly by Maine contractors and partly by the company's own force. In undertakings of this nature it is as necessary to organize a village as to construct the manufacturing plant, for labor must be brought to the place. When the contract for constructing this mill was signed last February, the only thing at Spragues Falls was a sign post. The nearest house was about two miles distant. A forest

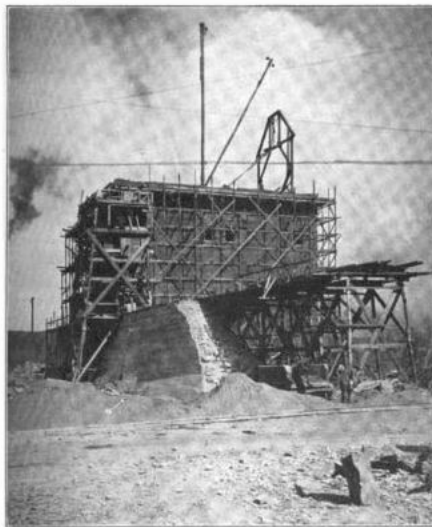
pend for transportation on a little branch railway in a remote corner of the country, there would have been plenty of facilities of all kinds. Workmen could have been secured without much trouble without going far for them, and tools and supplies could be procured as needed. In this case, there was not a single facility on which a contractor could rely. Everything had to be brought to the work long before it was



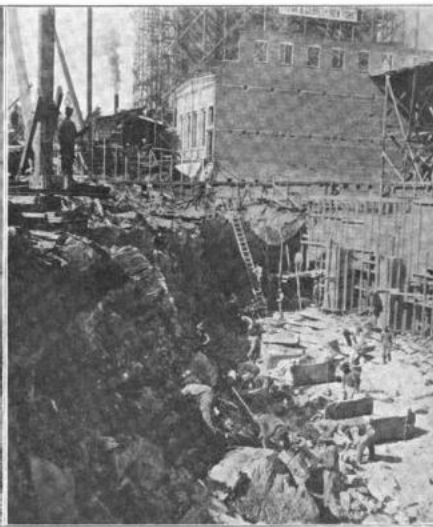
Concrete Plant on Island.



Construction of Main Dam.



Part of Digester House and Dam.



Excavation at Head of Tailrace.

which enabled a section with a sluice to be put in. The river was then turned through this sluice and the work continued. There are six of these sluices in all, which enable the river flow to be controlled without any trouble, although provision was made for handling a flood if one had occurred. The Washington County R. R. crossed the line of the main dam on the Canadian side and was kept in operation through a gap in that structure until a new line farther from the shore was built. A platform carried the workmen's runway over the track and was hinged so it could be moved out of the way to allow trains to pass.

While the plant itself was under construction a town had to be built, which was done partly by

stretched away for miles in every direction. Today there are good streets, about 250 houses for one and two families, a boarding-house for unmarried men, several stores, a good hotel with private bathrooms and other conveniences, a hospital, a church, a school, and ample railway stations and sidings. It has all been done so quietly that a few days ago a large moose, wildest of forest animals, was shot only a few hundred feet from one of the houses, a fact that will convince sportsmen of the newness of the town.

These facts are mentioned as illustrating one phase of the problem which confronted the builders of this plant. Its construction in a more settled section of the country would have been much less difficult. Instead of having to de-

needed, and in order to be on hand when required its use had to be foreseen. Working in this way, without a single detailed plan ready for use when the contract was signed about ten months ago, the practical completion of the dam and buildings to-day is an example of engineering and contracting ability that deserves the consideration of the old school of manufacturers, who take a year to plan a leanto and a decade to plan a blacksmith's shop. The achievement is a proof of the fact that the manufacturer who desires a new plant in a hurry will do well to turn its design over to an experienced mill architect and its construction to a contractor who has an organization ready to take up and drive the work to speedy completion.