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Development of power on Little Piney River

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THESIS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

SUBJECT:

"DEVELOPEMENT OF POWER ON LITTLE PINEY RIVER"

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Little Piney River has its source in the southern part of Phelps County, Missouri. Its general direction is north until its junction with Beaver Creek. Then it flows nearly due west and empties into the Gasconade River near Arlington, Mo. It drains an area of approximately two hundred square miles. The slopes of its drainage area being very steep, it is subject to large and sudden rises. As it is largely a spring fed stream its minimum flow is not far below its normal stage. The stream abounds in rapids with from a few inches to a foot or more drop in each one. For many years this stream has been used to furnish power for grist mills and the like, the method in such cases being to erect a small dam at such a point as was convenient and carrying the water down-stream to some point where the drop was sufficient for the purpose.

About two and one-half miles south-east of the town of Newburg, Mo. the stream makes a large loop shown on the accompanying map. It was thought that if a tunnel were cut through the hill at the neck of this loop that there would be possibilities of obtaining sufficient power to warrant the expense, so a reconnoissance survey was made with a view to obtaining more information concerning the locality. An examination of the stream valley showed that the flood plain was everywhere too wide to warrant the erection of a high dam and that the fall must be dependant on the natural fall of the stream. It was decided that the site of the old

Flint Mill dam (now in ruins) was the best place for a diverting weir. This place was about three fourths of a mile from the proposed tunnel entrance. The site of the diverting weir is conveniently located with reference to a large ledge of good limestone which would be useful in the masonry work.

The stream was gauged on this trip in the following manner: a stretch of the stream was selected that had a uniform cross-section, a base line was then measured parallel to the stream and its ends marked with stakes, brushes were then selected that would float with the greater portion submerged but not drag on the bottom. These brushes were thrown into the stream and the time required for them to cover the distance between the stakes noted. In this manner the velocity was found to be 3 ft. per sec. On taking a cross-section of the stream bed the area was found to be 28.9 sq. ft. The area multiplied by the velocity gave 86.7 cu.ft. per sec. as the discharge.

A line of hand levels were run from a point on the stream near the proposed tunnel entrance over the hill to the stream on the other side. Thedifference of elevation determined by this means was about 25 ft. With a discharge of 86.7 cu.ft. per sec. and a fall of 25 ft. the power would be about 246 horse-power.

There are several places where the power might be sold. The town of Newburg with a population of about 1000 and a division point on the Frisco R.R., is about two miles from the bend mentioned above. Rolla, a city of about 2000 inhabitants, is about 8 miles distant. St.James, a city of about 1100 inhabitants, is about 18 miles distant. All of these places could be relied upon to take more or less power, both for lighting purposes and for the operation of motors.

After making the reconnoissance surveys we decided that we would be justified in making better and more detailed surveys to determine more accurately the possibilities that were before us.

It was first necessary to run a transit (or angle) line setting stakes at every 100 ft. and hubs and guard stakes at the angles. Levels were then taken over these lines and the elevations at each station determined. A plat of the line was taken into the field with the elevations marked at every station and by means of the hand-level and pacing, the position of the five foot contours with referenee to the line was determined. In this way the topography was sketched in the field. The stadia line which begins at station 29 on the "F" line (shown in the accompanying blue print) was run to determine the course of the stream. All the lines were platted, and the topography, taken in the field, transferred and filled in with enough accuracy to serve our

purpose.

After the topographic map was made it was only a matter of good judgement to find the best location for the canal, tunnel and power house and it was only after a great deal of study that we decided that the best location had been found.

We projected the line as shown, then picked off the profile from the contours from which the quantities were computed. In computing the quantities for the canal we proceeded by using cross-section paper, platting cross-sections for every station and by average end areas determined the total excavation in the canal.

By means of a line of levels we found the difference of elevation between the water surfaces at a point near the site of the old Flint Mill dam, and a point across the bend almost due north of the first mentioned point, to be 35 ft. Taking the discharge as 85 cu.ft. per sec. we found that theoretically 338 horse power could be obtained from this discharge and fall, but the efficiency of the machinery must be taken into consideration. The leading manufacturers of water wheels guarantee an efficiency of 80% for their wheels, this would leave 270.4 horse power out of the original 338. The efficiency of a good dynamo is about 90%. This would leave about 243.4 horse power delivered by the dynamo, this horse power would be equivalent to 181.5 kilo-watts.

It is impracticable to transmit direct current a greater distance than three fourths of a mile, and since there is no possibility of having a purchaser of power at a less distance than two miles, it is of no use to consider direct current at all. Using alternating current, power can be transmitted to Newburg with an efficiency of 98%. It can be transmitted to Rolla with an efficiency of 96% and to St. James with an efficiency of 84%. The current should be generated at a voltage of 1100 and stepped up to 11000 volts for transmission by means of 1:10 step-up transformers, and at point of delivery it could be stepped down to any desired voltage by means of step-down transformers.

Following is an approximate estimate of cost:

CONCRETE.

Dam	200cu.yds.	@ $5.00	$ 1000.00
Wing-walls	50" "	" $5.00	$ 250.00
Head-works	90 " "	" $5.00	$ 450.00
Over-flow weir	20 " "	" $5.00	$ 100.00
Miscellaneous	250 " "	" $5.00	$ 1250.00
TOTAL			$ 3050.00

EARTHWORK.

Canal	72000cu.yds.	@ $0.30	$21600.00
Tail-race	1000 " "	" $0.30	$ 300.00
TOTAL			$21900.00

ROCKWORK.

Rock-fill dam	900cu.yds.	@ $2.00	$ 1800.00
Tunnel	2000lin.ft.	"$15.00	$30000.00
Canals	8000cu.yds.	" $1.00	$ 8000.00
TOTAL			$39800.00

POWER HOUSE.

Building	$ 750.00
Foundation and floors	$ 250.00
TOTAL	$ 1000.00

MACHINERY.

Water wheel	$ 1300.00
200 K.W. A.C. Generator	$ 6500.00
TOTAL	$ 7800.00

GRAND TOTAL $73550.00

SPECIFICATIONS

General. The works necessary for the edvelopement of power on Little Piney River are to be located on Johnson's bend about two miles from Newburg, Mo. and shall consist of:

(1) Dam for the purpose of diverting water into canal.
(2) Rock-fill dam across flood plain.
(3) Canal to convey water from dam to tunnel entrance.
(4) Tunnel through hill.
(5) Canal from tunnel to power house.
(6) Tail race connecting power house with stream.
(7) Power house.
(8) Machinery.

The location of these with reference to each other is shown on the topographical map accompanying the general plans.

The general plans shall be considered part of these specifications.

Concrete. All concrete shall consist of a mixture of one part (by volume) of cement to six parts gravel, with such amounts of water as the Engineer may require.

The cement used in concrete shall be of some standard brand of Portland cement equal in quality to the "Atlas".

No cement which has been damaged by moisture or otherwise shall be used.

No stone shall be allowed in the gravel larger than two inches in any dimension. The

The Engineer may change the proportions of the concrete at any time it becomes necessary.

The materials must be free from earth and wood and other foreign substances and shall be thoroughly mixed.

Concrete which has been mixed longer than one hour shall not be allowed to enter the structure.

The concrete shall be deposited in horizontal layers and the stone worked away from the exposed faces of the structure with a spade or other suitable instrument.

The forms shall be tightly built and on all ex posed faces, planed lumber shall be used.

In placing the concrete it shall not be thrown a greater distance than ten feet in any direction.

All old surfaces shall be thoroughly cleaned and roughened before a fresh layer of concrete is deposited.

No concrete shall be put in the structure in freezing weather.

Work must not be stoped within 18 inches of the top of the structure.

Dams There are two dams to be built;one across the stream bed to divert the water into the canal and another across the flood plain to prevent the stream from changing its channel.

The first mentoned dam is to be built of cyclopean masonry with the exception of the wing walls which are to be built of concrete.

In preparing the foundations for this dam all loose

material shall be removed until firm solid rock is reached. All cracks and crevices shall be filled with cement mortar.

No concrete shall be put in until the foundation has been accepted by the Engineer.

After the foundation has been accepted a layer of concrete shall be laid to a depth of three feet. Thereon shall be placed a layer of one man stone with a distance from each other not less than 3 inches and clearing the faces of the dam by at least 6 inches. A layer of concrete shall then be placed on the stones to a depth of 6 inches, care being taken that all spaces between the stones are filled with concrete. This process is to be repeated until the stones are within one foot of the top of the dam, when their use shall be discontinued and the remaining space filled with concrete.

The wings are to be built of concrete and are to be built simultaneously with the dam in order that a perfect bond may be obtained.

The dam across the flood plain is to be a rock-fill dam.

In preparing the foundation for this dam the excavation shall be carried down until stiff clay or solid rock is uncovered. the foundation must be accepted by the Engineer before work is started on the dam.

After the foundation has been accepted rocks varying in size from two cu. ft. or less shall be placed so that

as stable a structure as posible may be formed.

The up-stream face of the dam shall have a slope of 2to1 and the down stream face shall have a slope of 1/1/2 : 1. The width of the dam on top shall be 2 feet.

The earth excavated in preparing the foundation shall be placed on the up-stream face of the dam.

Clearing The whole width of the right of way shall be clared of trees, stumps, logs, brush and other perishable matter and all fences and buildings which come within the right of way shall be removed to, or beyond these limits.

Grading The materials found in excavations shall be classed as solid rock, hard pan, and earth, the Engineer being in every case the final judge as to the class to which any material belongs.

Solid rock will include all loose boulders containing one cu. yd. or more, and all hard rock in compact strata or ledges exceeding 6 inches in thickness, which, in the judgement of the Engineer, cannot be loosened except by blasting.

Hard pan will include all material, except solid rock, which, in the judgement of the Engineer, cannot be loosened except by blasting.

Earth will include all material of whatever kind which does not clearly belong to one or the other foregoing classes.

Whenever material of any kind other than earth is

found in an excavation, the Contractor shall at once notify the Engineer in charge, so that he may make the necessary measurements to determine the quantity. If the Contractor shall fail to give such notice, the Engineer may presume that the measurements taken at the time he first sees the material in question will give the true quantity.

Under the head of grading will be included all excavations and embankments needed for the formation of the canal and for all accessory works which may be directed by the Engineer.

The canal shall be constructed according to the standard sections shown on the blue print accompanying the specifications. All material taken from excavations shall be used as the Engineer shall in each case direct. Where there is any surplus beyond what is needed for embankments, it shall be deposited in waste banks. All waste banks shall be placed on the lower side of the canal and sloped on the side next to the canal with a slope not steeper than 1½:1, and be kept at least six feet from the edge of the excavation.

The Contractor when so directed by the Engineer, shall deposit at such convenient points as he may designate, any stone or any other valuable material which may be found in the excavation. All material so deposited shall be the property of the Company, and the Contractor shall be held responsible for its safe keeping until removed by the Company, or until the contract is closed.

All falls or slides from the sides of the excavations shall be taken out by the Contractor, and , except when due to his carelessness or neglect, will be paid for at the same price as other excavation.

Tunnel excavation shall include all excavation between the portals and the inside limits of the prescribed section.

Canal. The canal shall be constructed according to the standard sections shown on the blue print accompanying the specifications.

Where pervious material is encountered the canal shall be lined as directed by the Engineer.

Where the proposed water surface comes above the original ground surface concrete retaining walls shall be built as directed by the Engineer, and the canal excavation shall be placed next to the retaining wall on the side farthest from the canal.

When streams cross the canal line, over-flow weirs and sluice gates shall be constructed in accordance with the standard plans.

The head works are to be constructed of concrete according to the standard plans.

The tail race shall be constructed in accordance with the specifications for the canal.