Minnesota Works Progress Administration: Writers Project Research Notes.

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Version 3
August 20, 2018

MISSISSIPPI RIVER MATERIAL BY JOSEPH F. RUSSELL (ST. PAUL)

ST. ANTHONY FALLS - 5 pages - Geologic construction - disintegration - results of 90-foot superstratum breaking off in 1851 - location of crest of falls in 1850 - Dr. Chute's tunnel under falls - peril to adjacent mills because of erosion and crumbling portions of crest - disastrous results of tunnel from Hennepin to Nicollet Island - efforts by companies using power to protect falls - Governmental survey for same purpose - combined governmental and local protective measures.

WATER POWER - 6 pages - Technical discussion of water power possibilities at the Twin Cities.

WATER POWER IN REALTION TO SEVERAL PRIVATE COMPANIES - 4 pages.

HISTORY OF POWER DEVELOPMENT AT HIGH DAM FROM 1866 TO PRESENT - 9 pages.

REPORTS AND OPINIONS OF ARMY ENGINEERS, THE STATE LEGISLATURE, AND THE FEDERAL GOVERNMENT REGARDING CONSTRUCTION OF HIGH DAM AND THE POSSIBILITIES FOR ELECTRIC POWER THEREFROM - 6 pages

SKETCH OF ELECTRIC POWER DEVELOPMENT AT POINTS ABOVE THE TWIN CITIES - 4 pages.

DISCUSSION OF TYPES OF WATER POWER, PAST AND PRESENT - 6 pages

REPORT OF ENGINEERS (1925) ON SURVEY OF ST. CROIX RIVER - 5 pages

THE FIGHT BETWEEN THE TWIN CITIES OVER LOCATION OF FORD PLANT - 7 pages

HIGH BRIDGE GENERATION STATION OF NORTHERN STATES POWER CO. - 4 pages

HISTORY OF DAMS, TUNNELS, MILLS, CANALS, ETC. IN CONNECTION WITH WATER POWER, FROM THE FIRST GOVERNMENT MILL AT FORT SNELLING TO THE PRESENT - 10 pages

VARIOUS WATER POWER PLANTS OPERATED BY NORTHERN STATES POWER & LIGHT CO. 5 pages

FURTHER DISCUSSION (TECHNICAL) OF FALLS OF ST. ANTHONY. - 5 pages

USE OF POWER AT THE HIGH DAM BY THE FORD MOTOR CO. - 7 pages.

J. Russell

MISSISSIPPI RIVER PROJECT
(Hydro-electric Power)

The development of water power involves artifical regulation of streams, proper regulation of running water for several uses of water supply, irrigation, power and navigation can be effected only in the light of the physical relations, the relations in equity, and the more salient legal relations of water in streams.

In a state of nature-and also under intensive cultivation-little if any storm water flows over the land surface apart from the streams; the rain fall is absorbed by the soil and its vegetal growth, and the streams are supplied partly by springs but much more largely by seepage directly into their channels, this being the normal condition, in which streams are generally clear and nearly uniform in flow.

All parts of each stream are interrelated; increase or decrease in volume, in-wash of detritus, the initiation of fluctuation, or other changes in regimen at any point eventually affect the stream throughout; especially susceptible to disturbance at the source are clarety and steadness of flow at points whense water supply is commanly taken in the middle course where power development is customary, and in the lower course devoted to navigation.

Normal streams, being derived chiefly from seepage, are maintained directly by the store of water accumulated in the ground as the residuum of rains of preceding seasons and decades, and only inderectly by the current rainfall. In the humid part of the country the ground water within the first hundred feet from the surface has been estimated at some 25% of the volume of subsoil and rock, equivalent to 6 or 7 years rain fall. That is, it may be conceived as a reservoir of water 25 feet deep conciding in area with the humid region. This reservoir is the chief source of the streams avialable for water power and other purposes; it is also the reserve agriculture capital of the country, and the measure of productivity and habitability.

Under extensive clearing and cultivation, the store of ground water has been materially depleted. Recent determination based on records of 9,509 wells in the 9 states of Illinois, Indiania, Iowa, Kentucky, Michigan, Minnesota, Ohio, Tennessee and Wisconsin reveal lowering of the water table at a minimum mean rate of 1.315 feet, or with moderate allowance for new wells 1.13 feet, per decade, corresponding to an aggregate of 13.8 feet for the 80 years since settlement began. This lowering of the level of saturation corresponds with an actual loss of water averaging 5.2 inches per decade, or nearly 150,000,000 acre feet annually within the nine states.

The loss is due largely to increased run-off in freshets and floods, which are in increasing degree wrecking destruction of property and loss of life; while innumerable springs and smaller source streams have disappeared, and the regimen of nearly all streams has been impaired.

The recent researches demonstrate that the surface streams of the humid country available for water supply and navigation no less than power are interrelated through the ground-water reservoir in such wise that the regimen of each is dependent on the integrity of the ground reserve by which it is chiefly maintained. The essence of a stream resides in its continuity of flow; and this continuity of flow is in nature due absolutely and wholly to be continous supply from the store of ground water.

Since the water vapor which bathes the continent and tempers its climate is not all precipiated on the land over which it passes, but in part goes on over adjacent seas; since the part precipiated as rain and snow and distilled as dew is largely re-evaporated from soil and open water and especially from growing plants whose vitality it sustains; since the residuum mainly soaks into the earth, where it forms a reserve store for ground water for a period averaging perhaps 10 years; and since streams are fed chiefly from this ground water reserve, it follows that the fresh water of the country as a whole, it its form of vapor, rain, snow, dew, ground water, lake and stream, despite its essential unity and the interrelation of all the parts, is but an integer within the larger unit.

Water is the prime necessary of life. Fully five sixths of all human food, and indeed a like proportion of the human body, consists of water, chiefly in its simple form, partly in chemical combinations. It would appear that no vital process occurs in the absence of water or otherwise than as a manifistation of its inherent propetries. In the plant and lower animals yielding human food and clothing, water plays an equally essential role. Indeed without water the continent would be unproductive and unhabitable, and the lands of the plants but a dead world.

In this land as in other countries, water is the primary natural resource. Industrial and other forms of activities on which rest the power and growth pf peoples and states depend absolutely on maintenance of human life and population which in turn depend on food and measuralby on apperal; and whatever its breadth in land and wealth in minerals, no continent can sustain human life and population without sufficient water for drink and for production from the soil the materials for solid food and clothing.

As the prime necessary of life, the water of the country is, under that leading principle of our national existance, that all men are equally entitled to life, liberty and the pursuit of happiness, the common and indivisible possession of all,a possession in equity inalienable and indeseasible, since no constituent of the nation could alienate or divest himself of his share without surrendering his right to life, and so weaken the nation.

As the common property and equitable possession of all, water in any form, together with appurtenant lands or other resources may be administered in the public interest by municaplities, states and national government; but no public agency may in equity alienate or divest the people of any part of the common interest in the water, nor may it be equitably transfer any right to use of the water without just consideration in the public behalf. As the prime necessary of life and the primary resource, and as the common possession of all, water is in itself a special property, and its equitable administration is rightly the most sacred trust confided by the people in their choses representatives and officers.

While to the uses of water are diverse, they are not equally essintial to life and to that general development of the country on which its power and prepetuity must rest. Sinch life can exist without it for but a few days, the primary use of water is ~~consumed~~ for drink and other domestic supply in which it is consumed; since continous life can be sustained and generations maintained only through food and clothing produced by its consumption, the secondary use is for agriculture, including, irrigation, sinch the measure of industrial proficiency is the conquest and use of power, the next use of water in order of importance is for mechanical power, in which substance is not consumed though its movement is utilized; and since the activity of commerce are necessarily subordinate to the primary industries. The least essential use of water is for naviga-

MISSISSIPPI RIVER PROJECT

tion in which it is not consumed and only its inert corpus is utilized.

Mechanical power lies at the root of modern civilization. The raw materials of mechanical power, coal, oil, natural gas, and falling water, are bases for the larger part of transportation and industry. The control of them carries with it the control of industry and transportation, unless that control is modified by effective public regulation. Control of industry and transportation involves the control of modern life. Hence the monopoly of water power, and of the raw materials of mechanical power is among the most threatening monolopies.

In the light of recent progress in electrical application it is clear that over wide areas the appropreations of water power offers an equalled opportunity for monopolistic control of industries. Wherever water is now or will be hereafter become chief source of power, the monopolization of electricity produced from runnung streams involves monoply of power for the transportation of freight and passangers, for manufacturing and for supplying heat, light and other domestic agriculture and municipal necessities to such extent that unless regulated it will entail monoplistic control of the daily life of our people in an unprecedented degree.

A water power can be controlled and used by only one concern at one time. Therefore water power is a natural monopoly. Hence the prevention of injury to the public from a monopolization

of water power involves the whole question of the terms upon which the right to use water power site should be granted. It makes necessary a governmental veto power upon concentration of ownership, limitations of the term for which the franchise is granted, compensation to the public for value received, full publicity, and in general all those conditions in the permit or franchise which will help to safeguard the public against injustices over another, & give to the devepopment its greater usefullness to the whole community. The public regulation of railroads, and other public utilities, whose franchises involve the use of natural monoplies, offers an instructive analogy for similar regulation of water power.

G.V.

course devoted to navigation

MISSISSIPPI RIVER PROJECT

The falls and rapids of the streams have played an important part in the development of the state, since they determined the places of portages, in some instances the head of navigation, and later because of the water they afforded.

The Falls of St. Anthony determined the sites of both St. Paul and Minneapolis, the former at the point to which boats could conveniently ascend, and the latter at the power site itself. It is now known that within another mile of recession of the Falls of St. Anthony would have disappeared, and had this taken place before white man came upon the scene it is quite likely that the metropolis of the state would not be found in its present location. That the early settlers appreciated the value of the then-undeveloped power site is shown by the fact that within the shortest possible time after the news of the conclusion of the Indian treaties ceding the triangular strip of land between the Mississippi and St. Croix rivers to the government reached the territory, claims on the east bank of the Mississippi at St. Anthony Falls were taken up. While the amount of available water power of Minnesota suffers in comparison with that of most of our mountainous states, yet its character is of the most satisfactory sort,

since the streams are generally less subject to fluctuations in flow. The many lakes and swamps prevent heavy floods in the streams, and as a result, less heavy dams are necessary; furthermore, the consenquent greater regularity of the flow means less idleness of water turbines because of low water.

Owing to the lack of coal mines within the state, industries have been more or less handicapped by cost of generating steam power. What this handicap has meant is well shown by a comparison of the development of the manufacturing industries of Minneapolis and St. Paul, the latter depending on power from coal, the former using a fair percentage of water power. In 1914 the output of manufactured products in Minneapolis was valued at $187,000,000; in St Paul, at $68,000,000. What is particularly noteworthy is that at the beginning Minneapolis derived virtually all of its power from the falls, and this gave it such an initial advantage over St. Paul that the latter never has succeeded in over coming the handicap thus imposed.

But until the 80's St Paul led in pop. and wealth. Butler modify or expand this statement.

Source of information:

Minnesota History Bulletin, Volume 2

Mpls. Docs.

Russell

MISSISSIPPI RIVER PROJECT

(Water Power St. Anthony Falls)

The water power development at Minneapolis is so different in form from the usual development as made today, that it might be of interest to tell its story.

This city of enormous commercial wealth owes its beginning and its early development primarily to the great waterpower afforded by the Falls of St. Anthony which was, for many years the greatest of utilized water powers in the United States, and which up to 1880 furnished practically all the power used for manufacturing in the city. The total falls utilized by this power is approximately 70 feet and there is a total installed capacity in water wheels of approximately 55,000 horsepower.

The original development was made at the upper falls utilizing now a maximum of 50 feet head and developing, at times 40,000 horsepower. The other 20 feet of head are used at the lower dam where a maximum of 10,000 horsepower may be developed.

The mean flow of the river at this point is about 6000 second feet with a maximum approximately 60,000 second feet and an extreme low flow of 700 second feet. For navigation purposes it is a partially regulated stream, the regulation being provided by means of Government owned and operated reservoirs at the head

waters. These reservoirs have a combined capacity of 96 billion cubic feet and store water in wet seasons for discharge during the navigation season, being used then to maintain a 3 feet gage at St. Paul, 6 foot channel, which means approximately 6,000 second feet flow.

While these reservoirs are maintained primarily as an aid to navigation and absolutely without intentional benefit to the water powers on the river below their outlet, yet there is of course an indirect benefit during the low water period of the summer to all these powers where the increased flow due to them, can be utilized.

The Mississippi River in its course from Pokegama Dam to St. Paul, has a fall of approximately 482 feet, nearly all of which may in time be used for water development. In 1880 when the Water Power Census of the United States was prepared, there was only one power development throughtout this entire length, manely that at Minneapolis, whereas today there are many developments along the river.

The laggest concentrated fall in this stretch of river is at Minneapolis where, after flowing for several hundred miles in a channel cut, for the greater part through glacial drift which covers that region, it breaks through the limestone ledge and leaves the general prarire level for a channel between banks of limestone and sandrock, whose picturesque bluffs define its course below St. Anthony Falls.

These bluffs which mark the channel from St. Anthony Falls, and its juncture with the Minnesota River, are the result of a gradual recession of the crest of the falls which geologists tell us, took centuries to reach the present position.

For several hundred feet above this crest, the water flows over a limestone ledge, which at its lower end is about 16 feet in thickness. This ledge in underlain by the St. Peter sandrock approximately 160 feet thick at this point. The original crest, as stated was probably in the neighborhood of Fort Snelling and had gradually receeded to its present location. The water falling over the edge of limestone wore the soft sandrock beneath, undermining and wearing away this support until the limestone would break away in large blocks, always preserving a vertical face to the falls.

In 1868 the recession had become so serious as to threaten their ultimate destruction, for by that time it had approached to within 1,200 feet of the point at which the ledge feathers out to a thin ledge and ceases intirely. It was then feared that the river would possibly cut under the limestone covering and wear away the soft rock below until nothing but the rapids would be left. To prevent this catastrophe a large timber apron was constructed and is still maintained, which has effectually preserved the falls to the present time.

Further protective measures were deemed advisable and upon recommendation of a board of engineers appointed for this purpose, a concrete dyke or wall extending from one bank to the other under the ledge near its lower end was built in 1874. This dyke is a solid wall of concrete in contact at the top with the lower face of the limestone and extending into the sandrock a depth of 38 feet, and has a length of about 1,900 feet from end to end. This work together with the timber protecting apron previously mentioned was done by United States Government Engineers under acts of congress appropreating money for these purposes.

In the early days no attempt was made to utilize the full fall available, but only that portion between the crest of the dam and the top of the ledge upon which the dam rested. Later shallow tunnels were excavated and the water discharge through the ledge into them, thus realizing a greater head, and ultimately these tunnels were further excavated to their full depth so that now a maximum of 50 feet head is realized.

In 1776 Johathan Carver, a native of Connecticut, visited the present site of Minneapolis and was probably the first man to appreciate the beautiful Falls of St. Anthony as a prospective water development and nucleus for a settlement. It was not however, until 1821 that any use was made of this power for manufacturing purposes.

The Government had established in 1821 or thereabouts a military post at Fort Snelling and ~~it~~ for its own use erected a small saw-mill below the crest of St. Anthony Falls, connecting therewith

by means of a wooden flume. This mill constituted the first improvement for power purposes at this place and was in fact the first edifice erected on the site of the present city of Minneapolis, and was the beginning of a development which in later years became the boss of the manufacturing and commercial strength of the city.

At that time the waters tumbled over a limestone ledge and rapids below, between heavily-wooded banks, fifteen hundred feet apart, unrestrained by works of man, whereas today we find the free channel restricted to about five hundred feet in width and the limestone ledge at the crest covered by dams and apron, which control and direct the energy of the river for water-power purposes.

This is not complete.
Will list sources of information
on completed article.
My thought is, to assemble
all the available information
then write the final story.
Am I on the right
track?

Russell

Yes, but try not to go too technical.
M. S L.

J. Russell

Please stop and see me at your convenience.
Lucile Varness

MISSISSIPPI RIVER PROJECT

(First Water Power In Minn.)

At various points throughout the State sufficient heads of water coupled with fairly constant discharge rates, have made the development of power by water a profitable investment despite the fact that the installation of a hydro-electric power station usually involves a cost which is far in excess of the expenses necessary to develop a steam plant of the same capacity. The development of highly efficient water wheel electric generators, high voltage transformers, and transmission lines have made possible the utilization of power which heretofore was not available because of its location in isolated localities.

The first water power development in Minnesota was made in 1832, over one hundred years ago, by the United States Government at the Falls of St. Anthony. The plant which was installed for the purpose of milling flour for use at Fort Snelling was of comparatively few horsepower. The real pioneer in the development was C. C. Washburn who built, in 1866, what was then considered to be the largest flour mill in the country. It was the best type mill known at that time. The investment was 100,000 dollars and the output per day was less than 900 barrels of flour. This mill was the first of the many, with the result that subsequent developments of the sites were made from time to time, but it was not until after the construction of a dyke to control the flow of water and to

prevent the gradual recession of the falls that the maximum power at this point was developed. The improvements necessary were made at a cost of $900,000 to the city and the national government.

Increased demand for electric power brought about the development of the most promising sites, so that from 1919 to 1926 the water power output of Minnesota increased very markedly.

The importance of water as a source of power in the pioneer days is still apparent in Minnesota, but the advent of the steam engine rapidly relegated it to insignificance, until the arrival of the hydroelectric plant. Development of electricity by water power increased gradually until 1931, when the apparent peak of development was reached. Because the most advantageous sites have already been developed the resources which remain are hardly worth the expenditure required if their development should be undertaken. The amount of the power which has been made available so far is 289,289 H.P. The amount, as compared with the 203,000 H.P. available 90% of the time, is nearly the maximum amount which can be economically utilized because of cheap development of power by steam and diesel plants, in addition to the great expenditure of further developments.

From figures as given by the United States Geographical Survey, 2.24 per cent of the total Public and Municipal water power projects of the United States and 4.40 per cent of the total manufacturing and miscellaneous projects of the country have developed

in the state of Minnesota.

The ~~rank of~~ Minnesota ranks eighteenth in the Power Survey among all states as producers of electric power by hydraulic means, ~~is number eighteen,~~ and ~~according~~ according to total power is number twenty.

Rewrite this paragraph

In Minneapolis is located the site of the State's earliest, and one of the most extensive developments, at St. Anthony Falls. It was here that the milling city, Minneapolis received the impetus which enabled it to become one of the largest flour milling centers in the world. From the first major development of a few horsepower the site has been stepped up to a point where it is now possible to develop as high as 55,200 horsepower, almost half of which is still used to supply power for flour milling processes.

Further up the river, eleven miles above Minneapolis, is located a rather extensive development at Coon Rapids, which has a capacity of 10,500 horsepower (20 feet head). At the time the project was installed the steam power plant had not been perfected to its present degree. The hydroelectric installation was at the time a paying proposition, but since then the steam plant has progressed to the point where power can now be developed at a figure far below the figure at which it is developed by the Coon Rapids plant. The plant was designed and constructed in 1913-14. ~~The~~ Its ultimate capacity ~~of the plant~~ was to have been 15,168 horsepower. The length of the dam is 2,070 feet. The average head is 17½ feet.

On the site of the Government Dam, commonly known or called the high dam in the Twin Cities, the Ford Motor Company has installed a hydroelectric plant with pulverized coal auxilliary steam units. The head varies from 22 to 36.5 feet, with a maximum head being available during the winter months. In this instance, as in the others throughout the State, when the power available cannot be consumed at the site, it is purchased by the Northern States Power Company.

In the vicinity of Little Falls the potential power of the Mississippi has again been utilized to very good advantage by development which exceeds 26,000 horsepower. The Minnesota Power and Light Company here once again takes the lead with a 18,200 horsepower plant located in Morrison County.

The Watab Paper Company at Sartell has a 7,800 horsepower installation available, of which output all but 1,680 k.v.a. is used directly for manufacturing processes.

Undeveloped water power resources in the State are numerous, but the expenses connected with their development would probably be too high to permit the utilization of this power. The nature of this land in Minnesota does not permit the location of large storage reservoirs, nor high heads, and the flow of water is not continuous throughout the year, due to storage of water during the winter months and the retention of moisture by growing plant life in the summer. Flow is therefore

heaviest in the fall and spring, and must be considered in conjunction with maximum flow in order to ~~safely~~ develop the enterprise safely. Records of stream flow, topography surveys, and the location of reservoir sites have a very great bearing on the future enterprises throughout the State. It is unlikely that steps will be taken in the near future to develop the less favorable sites because cheap power available by steam electric plants and ~~Because~~ the best heads have already been developed.

Sources of Information:

Edgar, W. C., Medal of Gold. Minneapolis, Minnesota. Bellman Company, 1925.

National Aspects of Water Development. Natural resources Production Department, Chamber of Commerce of United States, Washington D. C. Sept., 1930.

Water Power Development. Chicago & New York. A. W. Shaw Company. 1928.

J Russell

MISSISSIPPI RIVER PROJECT

(Early Water Power On Mississippi In Twin Cities)

Following the erection of the Government mill at Fort Snelling, it was not until 1847 that any serious improvement for water power purposes was undertaken. In that year the owners of the property at the east end of the falls built the first dam, of logs of sugar maple and elms cut on Nicollet Island.

This dam ran across from the east shore to Hennepin Island, thense up to the foot of Nicollet Island, forming what has ever since been known as the St. Anthony mill pond. Water flowed into this pond around the east side of Nicollet Island, and was discharged over the limestone ledge below the dam, utilizing but a small fraction of the total head and power available.

The water power is owned and operated by two companies, the Minneapolis Mill Company occupying the west side, and the St. Anthony Falls Power Company on the east side.

Both companies obtained their charters in 1856, and proceeded to build a system of timber dams, designed primarily for the purpose of handling and sawing logs. The channel on each side was closed by the construction of dams extending toward the center of the river several

feet, thereby connecting wing dams extending upstream towards the center, the present V shaped dam was formed.

These dams reduced the natural spillway over the falls from something over 1,200 feet to less than 500 feet, which concentration of flow increased the resources of the crest at an alarming rate. From 1857 to 1868, this recession is said to have been about 288 feet and then was considered serious enough to call for protective measures, which were begun in 1866. It was not, however, until several years later that the apron was finally completed in its present form. There has been no appreciable change at this point since that time.

In settlement of certain disputes between W. W. Eastman and the St. Anthony Falls Water Power Company concerning flowage rights, the power company granted to Eastman power rights to be used on the lower end of Nicollert Island. In the fall of 1868, Mr. Eastman began to tunnel from a point below the dam on Hennepin Island under the ledge to create a tail race for mills to be located on Nicollet Island. This proved to be a disastrous venture, as water broke through into the tunnel and for a time threatened complete distruction of the falls.

After the water power owners, aided by the citizens, had reached the limit of their resources in an effort to avert a catastrophe, Congress was called upon for aid, and the matter was regarded of sufficient importance to warrant the Government in undertaking the preservation of the falls, The resulting action by Congress placed the matter in control of the army engineers, and in the appropriation of funds which were ultimately applied in constructing the dyke and apron.

The two water companies were for years operating in a competitive manner, which resulted in much friction and waste of power through lack of cooperative effort. During periods of low water no attempt was made to preserve the head and the storage of power resulted in a scramble between lessees of the two companies for water, carried to the extent of draining the mill ponds down to the lowest point that would allow water to flow into the canals. Thus, through the diminuation of the head, the power was largely wasted at the very time when it was most important to conserve, and use it economically. Furthermore, there was lack of control by either company over its own lessees, so that for many years this useless waste continued unrestrained to the detriment of all.

These conditions lasted until about 1889, when a consolidation was effected, bringing the two companies under the control of a single governing head with a highly beneficial result to both companies and their lessees. Although today, the seperate corporations are maintained and the business is still carried on individually by the two companies, yet being under one management, the greatest harmony and cooperation is effected.

The early use of power was confined almost entirely to the running of saw mills, but subsequently there were established a variety of industries, including wollen, paper and flour mills, machine shops, etc. In the course of time, however, the manufacture of flour became the principal industry.

In the beginning, and for many years thereafter, this development did not prove to be a particularly profitable venture, and the owners struggled along, paying high rates of interest on barrowed money, with no appreciable returns to compensate them.

On the site of the Government Dam, commonly known or called the high dam in the Twin Cities, the Ford Motor Company has installed a hydroelectric plant with pulverized coal auxilliary steam units. The head varies from 22 to 36.5 feet, with a maximum head being available during the winter months. In this instance, as in the others throughout the State, when the power available cannot be consumed at the site, it is purchased by the Northern States Power Company.

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operate to its maximum capacity, but as this capacity increased, the normal amount of water became inadequate, so supplementary power in the from of steam or electric power had to be installed to make up the deficit in low water periods. There were periods of every year, however, when there was more than sufficient water to fulfill the requiremants of the leases, and it was then that the surplus or excess was sold.

It is to be regretted that the early development of St. Anthony Falls was begun and continued with very little, if any, application skill. The engineer was apparently thought unnecessary, and the only kind of evidence which can be found was the so-called common-sense engineering done by rule-of-thumb and aiming only for immediate results. The effects of this early shortsightedness is still being felt and some of the mistakes made at that time will never be overcome.

Soon after the consolidation in 1889, extensive improvemnets were undertaken by the water companies, resulting in greatly increased economy. Tail races were deepened and widened and many thousands of dollars were spent to make the power of greated use and value to the lessees. Regulations for the use of water in accordance with the priority of lessees were promulgated and inforced, and the use excess water was subjected to control. From that time on, the level of water in the mill pond was maintained at the maximum elevation possible, thus reducing the losses due to diminished head.

In 1894 the main apron over the falls was almost entirely rebuilt along substantial lines, and many of the mistakes of the earlier design were corrected. Additional spillway capacity was provided on the east side by the construction of a waterway 50 feet wide which aided in reliveing the concentration over the main apron, and later in 1897, still another 50 feet was provided by construction of another waterway adjacent to the first.

The generation of electric power in Minneapolis on a commercial scale by water power began in 1894, when the Minneapolis General Electric Company built its Main Street station at Third Avenue S. E. There had been, previous to this time, a small plant near the lower end of Sixth Avenue South, but it was operated for a short time only.

The common method of using water power in the mills is by means of a turbine on the lower end of a vertical shaft, on the upper end of which was fixed a bevel gear engaging a similar gear on a horizontal jack shaft from which the power is distributed throughout the mill by means of belts or rope drives. Some mills are equipped with horizontal wheel settings which drive onto the mill shafts by rope or belt drives. A later development provided for a motor attached to the same horizontal water wheel shaft so that when the water power was sufficient, electric current from steam driven generators were used to make the power deficency. The motors were so connected, that they could be at any time be used as generators, when there was an excess of power available., thus enabling the transmission and use of the excess power at some other place. In still other instances

where the mills have been abandoned for manufacturing purposes, the buildings have been turned to another use by the installation of small individual hydro-electric plants using the leased water for electric power purposes and transmitting it to adjoining mills.

The use of auxiliary power, either steam or electric, is quite unusual, and in quantity is now nearly equal to the total normal amount of water power used, so that the mills can operate even when the water supply is at a mimimum. For this purpose, there is at present a total of approximately 23,000 steam horsepower available which is used directly through through reciprocating engines or indirectly through steam turbine generators and motors. The total electric motor installation for all purposes is approximately 12,000 kilowatts.

The most recent and probably most economical application of steam power is used by means of steam turbines directly geared to the main line shaft of the mill, thus eliminating all intermediate drives with their unavoidable loss of power. It is claimed that this arrangement will put a horsepower on the mill with a consumption of only 11.4 pound of steam, which will result in an energy cost approaching closely the cost of water power.

In 1908 the St. Anthony Falls Water Power Company completed an hydro-electric station on Hennepin Island, designed primarily to use surplus water power during periods when the flow exceeded the requirements of the manufacuring industries then leasing water, and which otherwise would pass over the dams and its energy be lost. At the time of its conception,

a plant designed for this particular purpose was unique.

There were many water power developments having an excess of generating capacity way beyond the limits of permanent power available, but this plant, even today, stands almost alone as being deliberately conceived and built to utilize only such power as is available during times of high water and standing entirely idle for several months of each year.

It is only the recent developments of the times that have made such a project feasible and only the most favorable conditions have made possible its satisfactory results.

In this case, the three controlling factors were water supply, low development cost, and suitable market for power of this class. The first factor, water supply, was the primary one when the project was first considered. Investigations covering the records for a period of years, indicated that, with a plant properly adapted to the conditions, a sufficient amount of power could be obtained to justify the undertaking, provided the cost were not excessive. Preliminary estimates of cost proved satisfactory and construction work was begun. Obviously, economy in this was essential, as it was to have a direct bearing on the rate for which the power could be sold and a market for power of this nature could be found only at a very low price. The low development cost of $26,000 per horsepower shows how effectually the desired economy was attained.

This plant now known as the Hennepin Island Power House, draws water from the old St. Anthony mill pond through a canal 55 feet wide and 350 feet long, discharging it into a long tail race below from which it is returned to the river a few hundred feet above the Lower Dam development belonging to the same company.

The canal is built over the limestone ledge with heavy walls of

the same material and terminates at the power house, which is built across the lower end. Suitable steel frame, motor operated head gates between concrete piers are provided at the entrance to shut out the water for cleaning or other purposes.

The power house a massive structure, the foundation of which rests upon sandrock, is built of masonry, brick and steel, and covers all hydraulic as well as the electrical equipment.

It was originally planned to provide for two units of 3,000 horsepower capacity each, but the plant as completed has installed a total generating capacity of 12,000 hydraulic horsepower, with 9,000 kilowatts electrical energy capacity, besides duplicate water wheel driven exciter units.

Water from the canal passes through the trash rack into four large steel plate penstocks, thence through the wheels and draft tubes to the tail race below.

As this plant is operated auxiliary to the Street Railway Company's steam plant, the wheel gates are usually wide open and very little regulation is required. However, modern wheel generators have been provided and are always ready for emergency service.

The generators are of the horizontal shaft type, each directly coupled to a pair of turbines and are designed to generate 2,250 kilowatts each at 13,200 volts.

The entire output from this power house amounting in 1916 to about 35,000,000 kilowatt hours was used by the Twin City Rapid Transit Company, who operate the plant in parallel with their steam and water power stations.

In 1898 the St. Anthony Falls Water Power Company completed the Lower Dam development, which is located about $\frac{1}{2}$ mile below the Upper Dam, at a cost of $956,000. It is approximately 1,000 feet long and varies from

15 to 20 feet high and the entire structure rests upon a solid concrete foundation which penetrates the sandrock to considerable depth.

Today the hydro-electric plants are operated at practically full available capacity all the time, supplemented by steam nearly continuously.

During 1919 the available powerfrom these two plants was approximately 97 million kilowatt hours, all of which was used for street railway service in the Twin Cities.

Thirteen miles above Minneapolis is located at Coon Rapids hydro-electrical development of the Northern Mississippi River Power Company, which was completed and put into service in 1915.

At this point the river flows over a soft bottom, which presented many difficulties to the designing and constructing engineers. The development comprises a structure approximately 2,000 feet long, including 1,000 feet of spillway section and 630 feet of earth embankment. This entire structure rests upon round wooden bearing piles and for the greater part is provided with a double row of steel sheet piling.

The low head of 18 feet is utilized advantageously be means of vertical single runner water wheel units direct, connected to General Electric generators rated at 1,625 K. V. A., running at 62 revolutions per minute. Motor driven exciters are used, obtaining their storage current from the other stations of the system.

The spillway section is of the gravity type with 28 Tainter gates, producing a maximum depth on the crest of 8 feet. It is designed to pass a flood stage of 80,000 second feet. This development, at the time of its completion, represented the latest and most approved practice in hydro-electrical development, and the results obtained from operation were highly satisfactory.

Below St. Anthony Falls, was constructed the now famous so-called "high dam" by the United States Government in conjunction with locks for navigation purposes.

F.V.

J Russell

MISSISSIPPI RIVER PROJECT

(Steps in Water Power Development)

To form an intelligent opinion of the probable future of water power development, it is necessary to refer briefly to some of the many different types of water power and to some of the characteristics which determine their economic value.

Primitive devices for utilizing water power date back to earliest historic times and before the advent of the steam engine, water power was the only important source of mechanical energy. Until near the close of the last century it was generally recoginzed as the cheapest form of power and in order to make use of it, mills and manufacturing centers were established along streams at the most desirable power sites. In recent years the rapid development of the steam turbine, the use of higher steam pressures and temperatures, and improvement in power house design have increased fuel power competition.

At particularly favorable sites, however, it may be possible to produce water power at a very low cost. One of the types of low cost development is provided by streams having steep profiles where there is an opportunity for cheap diversion and the water can be carried through a short canal to a precipitous drop back to the stream. Another type of development favorable to low unit cost of power is found at sites on streams so large as to make the cost of the dam

small in comparison to power output. Natural "falls" sometimes have possibilities of low cost power. The desirability of developing such projects is necessarily subject to market for power. The cost of developing power at the more favorable sites may be as low as $75 per kilowatt installed but commonly it will range from $100 to $300. These figures, however, have little real meaning without accompanying data regarding the water supply available for power generating purposes. It is important to understand that there is not a fixed relation between cost per unit of installed capacity and the cost per kilowatt hour of output, since the latter depends as much upon the amount of variation in flow of water at the site as it does upon the unit cost of installation. Unless water power can be used in the immediate vicinity of the power site, the cost of transmission must be added to the generating cost to obtain the cost of delivered power.

It is important also to understand that all the water power output of any given plant is not of equal value. Most streams have extremely variable flows, the maximum flow being 50 or more times the minimum. The installed capacity of modern plants is ordinarily capable of using many times the low stream flow. The water power available every day of the year, that is the power corresponding to ordinary low-water flow, is termed "primary power." Secondary power is the remaining power available only part of the time. Clearly, the primary power has much greater value than the secondary power. Storage is utilized to augment low-water flows, thereby increasing the primary power. The ideal storage would make the entire flow

of a stream available in accordance with the power demand. Storage possibilities are dependent upon the availability of economical reservoir sites.

Unit investment in water power projects including transmission remains on the average substantially as it was before the war. Higher prices of labor and material have tended to increase costs, while other factors have counteracted this tendency. For example, the newer projects particularly those forming a part of an interconnected system of steam and water power, are developed to use a larger percentage of the stream flow than formerly was profitable.

This increased the cost of power-house and machinery, but does not affect the cost of dam or right of way, and the increases in plant cost is not, therefore, in proportion to the increase in installed capacity. Improvements in plant efficiency resulting from improved design of water wheels, intakes, and draft tubes, have tended to reduce the unit cost of installation. Also, the greatly increased demand for power in recent years and increasing range of commercial transmission have permitted the development of large projects which before were not economically feasible.

In many instances a limited amount of comparatively cheap water power is produced as a by-product of navigation improvement, land reclamation, or domestic water supply, the last depending more or less upon the division of benefits. The amount of energy produced from such joint development is increasing but constitutes only a small part of the total water output of the State.

There has grown up a custom of measuring the value of water power in terms of steam power cost. Not only is this done by power companies but commissions and courts use the cost of steam power as an index in fixing rental charges and payments for damages, flowage rights, and rights of way. On this basis the value of an undeveloped power site becomes the capitalized saving in cost of its power output, delivered to the load center as compared with the cost of equivalent steam power. Though it is impossible to apply this method with any degree of accuracy, an attempt to use it in fixing the value of a power right tends to neutralize any natural advantage which water power may possess. It is obvious that if the investor be required to pay for an undeveloped power site, the amount which represents the capitalized saving which would result from its use, he will prefer to build the equivalent steam plant which generally can be done at a much less initial investment.

Since a power source must be equipped to supply its load requirement at all times, a water power plant operating as an independent unit is limited in its output to primary power and water in excess of the minimum flow must be wasted. Under unusual conditions a special market may be found, for secondary power, but this power usually has little market value and would seldom justify the installation of machinery for short time use. On the other hand, steam plants in good state of repair can operate at full capacity throughout the year. For these reasons a water power plant on a stream of variable flow operating as an independent unit

will not be able to compete with a high grade steam plant. Water power is best utilized in conjunction with some source of auxiliary power which makes the secondary power available for general commercial use.

It is most valuable when it forms a part of an interconnected system of water and steam power. Some of the foremost problems concerning the best use of water power relate to interconnection with steam power and to the possibilities resulting therefrom of providing better service and conserving capital.

Water power with pondage is particularly valuable as a part of an interconnected system of steam and water power. With such combined use the economical development of streams not regulated by storage is feasible for beyond the minimum flow and the waste of water during higher stages is largely eliminated. Such a combination also enables the water power to carry daily peak loads during the period of low stream flow while steam power is being generated at a comparatively uniform rate to supply the base load. This method of operation is often economical since the cost of water power is practically independent of load factor while for steam power the cost increases inversely with load factor. The combined operation of water power and steam plant also gives value to secondary power since the use of this power saves fuel and provides convenient periods for shutting down steam units for repairs. This in effect saves the cost of reserve steam capacity. The advantage of interconnecting steam and water power is less marked if the latter does not have pondage.

The Mississippi and its upper basin tributaries generally have their sources in a flat highland, flow through lakes with broad outlets and through broad valleys, and therefore offer no opportunity to create artificial storage of any consequence, or for the construction of dams of any height. On the whole the development of hydro power must depend upon the occasional stretches of rivers which offer suitable heads. There are very few places where more than a 30-foot head could be obtained. Paper mills established early in Minnesota, naturally made use of best power sites. Other industries have preempted additional sites, and all of the best hydroelectric sites in the Mississippi basin itself are now developed.

While the total possible installed capacity is impressive, it must be observed that many projects are based on as little as 20 percent time flow of streams. Thus it is evident that the cost per k.w. of development for prime power available is much higher than the cost per k.w. of installed capacity. It is not likely that many of the possibilities of power will be built under present conditions in the industry, as under such conditions fuel-burning plants are more economical. On the other hand, in a more highly integrated power industry utilizing all plants to capacity, a considerable number of these hydro sites might economically be absorbed into the system.

1/13/38

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Russell

MISSISSIPPI RIVER PROJECT

(St. Anthony Falls Water Power influence on Mpls.)

The Falls of St. Anthony have played such an important part in the development of milling in Minneapolis, that they deserve special mention. In 1914 the developed power was approximately 60,000 horsepower under an average fall of 47 feet. This power, with the exception of 12,000 horsepower in the Hennepin Island station used by the Street Railway Company is practically all taken by the flour mills. The races from the mills and this island station discharges into the pond of what is called the Lower Dam. This gives another fall of 18 feet, and is used entirely in a second plant, where 10,000 horsepower is generated for the use of the street railway company. The Hennepin Island Station is an excess plant and is run only when the demands of all other users are satisfied.

The unit of measure is the mill power defined as 30 cubic feet per second under fall of 22 feet or approximately 75 horsepower gross. The mill powers are numbered from 1 to 48, there being in many cases several having the same number. Under conditions of limited water supply such as occur in the winter months, the mill powers are cut off in the inverse order of their priority number. That is, series number 48 would be taken off

first and so on down the line until a balance was reached betweeen the available supply and the amount used. It is under such conditions that the steam relays have to be used. Early in the history of the mills, these mill powers were owned or leased by various mill owners in proportion to the power they used, and the water company was something in the nature of a cooperative organization. The rental of the early powers was but nominal, which gave so little for dividends, that free powers were given instead. These free powers and also the leased powers were perpetual and non-assessable. As the value of the power began to be appreciated, the rental increased when new leases were made to where $1,000 per year was charged for series number 48.

In the water power development of the main falls, there is nothing that could be rightly called a dam. Underlaying both sides of the river and falls, is a limestone ledge which is about 12 feet thich on the downstream edge and which tapers in thickness as it extends upstream to where it stops some 1,200 feet above the falls. In fact it is like a shingle with the thin edge lying upstream. The down stream edge of the ledge is in the form of a great hollow square or horseshoe whose sides extend down stream at the upper end of the hallow aquare in the center. This is an apron which protects the face of the ledge and slopes from the top of the ledge to the pool below. Starting from the end of the apron, extending up stream, and built on top of the ledge is an elongated U shape, is a dam which gives a depth of water of 14 feet, above

the ledge, forming the mill pond, from which the water is taken in canals to the mills. The water spilt over the dam on to the ledge and down over the apron. From the end of the apron and forming a continuation of the dam, are walls built on top of and following the edges of the ledge downstream. These walls form the river sides of the main head races to the mills, one on either side of the river. The mills on the river side of the head race have their front walls built on the wall of the canal and their back walls extend down to tail race level, making them some three stories higher in the back than in front. These mills take their water supply through penstocks and the waterwheel discharge directly into the main tail race. The mills on the side of the head race take their water through canals from the head race into open flume waterwheel settings. These wheels discharge through holes cut through the ledge. From these wheel pits tunnels are cut under the ledge of the main tail race. The formation below the ledge is a tightly compressed white sand which just misses being sandstone, and it is through this that the tail races are cut. Most of these races are lined with concrete or brick up to the ledge, the ledge making the roof.

Water power development in its present form was not reached without as many serious mishaps as befell the mills in their evolution. The earlier retaining walls and canals were timber and crib structures and there were many wash-outs, even

carrying entire mills away. In 1870 the most severe washout occurred. Through a break on the east side, almost the entire river ran under the ledge, and it looked as if the Minneapolis water power were a thing of the past.

It was then that the Federal Authorities were called upon for help. Congress appropriated over half a million dollars, and with this a dyke or cut-off wall was built across the river under the bridge.

In the early days there was no attempt made to maintain a uniform head of water by limiting the amount each mill could use. When the water was low it was just a grand scramble to see who would get enough to keep their mills running. Stories are told of how, when there would be but two or three feet of water in the canal, the crew in one mill would build dikes of sand bags and boards to divert the water into their wheel pit. Then the crew from the mill below them would try to tear out the dyke, so they could get the water. A fight would ensue with material damage to the heads of the party having the smallest number of picks and shovels. The power on the east side of the river was controlled by the St. Anthony Falls Water Power Company, and on the west sideside by the Minneapolis Mill Company.

There are within the city limits of Minneapolis and St. Paul five steam generating stations with a combined capacity of 165,400 kilowatts.

These plants give assurance of prefectly reliable service even with severe stroms which might effect the transmission lines from the hydro plants.

While the capacity of the hydro plants is less than that of the steam plants, they may during a good water year supply fifty per cent or more of the kilowatt hour requirement of the system. Like most waters with the exception of Niagara, the flow of the river is variable and during certain periods of the year a large part of the energy must be generated by steam.

P.V.

J. Russell.

MISSISSIPPI RIVER PROJECT

(Story of Power Development In Twin Cities)

In 1910 a board of the United States army engineers reported in favor of the construction of a high dam in the Mississippi river near the Soldiers' home and suggested that the cities of Minneapolis and St. Paul should cooperate and acquire the power for public use.

The Board of Engineers for Rivers and Harbors concurred in the recommended that negotiations be entered into whereby the cities of Minneapolis and St.Paul should become lessees of the surplus power that might be developed.

In the River and Harbor act of 1910 Congress adopted the project as recommended by the chief of engineers, with the proviso that in the making of the leases for water power a reasonable compensation shall be secured to the United States and the rates as fixed shall be subject to revision by Congress.

At the next session of the legislature of Minnesota a bill was passed premitting the formation of public corporations for the purpose of developing water power. Under this act the Municipal Electric company, composed of the University of Minnesota and the cities of Minneapolis and St. Paul, was formed.

This corporation subsequently made application to the Federal government for a license on the water power.

The application was denied on the ground that until new legislation was passed by Congress the secretary of war was without power to act.

Subsequently Congress passed an act by which municipalities in the vicinity of a water power developed by the government should have the preference in obtaining a lease of the rights.

The state law which authorized the creation of the Municipal Electric company was defective in that it made no provisions for financing the project. At the session of the legislature a bill was introduced to supply this defect. The bill was defeated.

The federal government called for bids for the power in the spring of 1921. St. Paul assumed that the Municipal Electric company was without power to function, and without consulting either the University or the city of Minneapolis in making application for the power for its own use. It declined to join with the University and the city of Minneapolis in making an application in the name of the Municipal Electric company which could be done only with the assent of the three parties. Minneapolis then presented a seperate application in its own behalf. The University, having no power to act without legislative authority, made no application. An application was also presented by the Northern States Power company. The federal Power commission, to whom these applications were presented, granted hearings to the parties and, after the parties had been heard and the subject considered, entered its order postponing a decision on the merits until the state of Minnesota and the cities of Minneapolis and St. Paul could have time to reach an agreement, if possible,

and until the legislature convening in January 1923 could consider the subject.

It semmed proper for the member of this board who sat as its representative in the Municipal Electric company to report his views upon the situation and make such recommendations as were in his judgement best for the interests of the public.

He felt free to do this without first conferring with the representatives of either of the cities as St. Paul had already declined to act with the other members of the Municipal Electric company, and had announced its determination to obtain the power for itself, if possible.

There were objections to the University of Minnesota acting with the two cities in seeking the use and control of this power. The first was that the University should not entangle itself in any problems which in the end would tend to enmesh it in political discord. The cities themselves were in controversy. A private corporation, with large political influnces was seeking the power. The state also it was felt, should avoid the entanglement. Next to the federal government the state had the first right to the power. The second was that the state of Minnesota had problems of its own so vast and far reaching for the good of its own people that, if it could be shown the power had real value to all the people, then the state should alone, and not in conjunction with anyone else, acquire and control it.

There were many problems related to the development of the state and the advancement of its commercial, industrial, agricultural, and civic life, which it was felt would have been served by taking over the power, developing it and using it in the manner and purposes as:

1 - Improvements looking to the higher effiviency of methods of fixing astmospheric nitrogen and the manufacture therefrom of artificial fertilizers and various other products;

2 - Smelting of iron and steel from the ore;

3 - Refining of steel and development of new steels:

4 - Purification of city water supplies;

5 - In oculation of sewage;

6 - Reconstruction of native stones into more valuable materials;

7 - Development of new artificial material for highways or pavements;

8 - Extraction of aluminum from common clay;

9 - Application of electricity to plant growth and to agriculture;

10 - Utilization of forest and other vegetables products now but partly utilized;

11 - Purification of atmosphere from smoke, dust or fog;

12 - Electrical reduction of peat;

13 - Development of off-peak and seasonal loads od water-power;

14 - Determining of conditions under which known electrical phenomena may become the basis of commercial processes;

15 - Making of new discoveries of properties of matter and its behavior.

A large part of the electricity to be generated at the proposed site of the high dam to be palced under of the research and teaching staff of the University, for the purpose of working out these problems.

A very considerable part of the electric would be used in lighting the University buildings. Power not used for research and lighting purposes could be carried to Stillwater and used for extracting nitrogen from the air and the manufacture of fertilizer for the farmers of this state, as binding twine is produced. Such a plant would be a suitable adjunct to the State Prison and to construced in ubits of 2,000 kilowatts or more. There are beds of limestone within easy reach of Stillwater suitable for use in making nitrates.

Supplementary steam power could be supplied by installation of steam turbine units at the main heating plant on the University

campus and connected by transmission line with the power plant at the dam.

Besides these benefits to the people of the state there would be the indirect advantage of holding a check over the Northern States Power company - thus enabling the state to know the cost of generating the power.

The amount of money paid since 1916 annually by the University to to Minneapolis General Electric company for electricity used on the main campus was;

1916-17	$ 9,292.12
1917-18	8,706.49
1918-19	10,506.41
1919-20	12,413.99
1920-21	14,918.53
	$55,837.54

In addition to this the University furnished some electricity from a small plant operated by itself for educational purposes.

The Agricultural campus was not connected by any transmission line with the main campus. Heretofore all electricity used on that campus had been generated on the campus by the University. It was therefore recommended that the Board of Regents express its sentiment in favor of the state of Minnesota taking over the power at the high dam for the use of the people through its university and its State Prison and report its action to the governor of the state with the recommendation that the governor take such action as will result in a careful consideration of the subject in order that the

intrests of the state in this power may not be overlooked, but rather be fully protected by suitable legislation at the next session of the legislature.

Excerpts from a plan submitted to Board of Regents, by Fred B. Snyder member of the Board of Regents.

S.V. 3/11

J. Russell

MISSISSIPPI RIVER PROJECT

(History Water Power Development In Twin Cities)

Power development at the high dam, has a history that dates back to 1866. The Following ~~is a chronogoly which~~ chronology of events shows each move in the waterpower situation.

1866, July - Major Warren, corps of engineers, of the United States army, assigned to duty of "examining and surveying the upper Mississippi river and its tributaries between St. Anthony Falls and Rock Island."

1866, December - Legislature of Minnesota petitioned Congress for appropreations to improve river at Meeker's Island, three miles below St Anthony Falls.

1867, - January - Report submitted by Major Warren recommending construction of a lock at Meeker's Island; lift to be 13 feet, cost to be about $235,000. Stated that"if a vessel could be brought up to Meeker's Island it could accommodate all requirement for the present for both cities of St. Anthony and Minneapolis.

1868, July - Act of Congress made a large grant of public land to the state of Minnesota to aid state in constructing lock and dam in accordance with Major Warren's plan.. Congress provided, however, that if lock and dam were not built within two years after acceptance of grant, the land should revert to the United States.

1868 - Major Warren reported another lock and dam would be required near mouth of Minnehaha creek (site of present high dam).

1873 - No work having been done by Minnesota on the Meeker's island project, Congress ordered that all claims to land grants be relinquished and appropriated $25,000 for improving Meeker's Island.

1894, Aug., 18 - In spite of constant efforts in the 26 year period following the unused land grant of 1868, no definite project was launched. In the 26 years a total amount of $59,098.70 was spent in dredging,bank protection and wing dams, between the Chicago St. Paul, Minneapolis and Omaha railway in St. Paul and the Washington Avenue bridge in Minneapolis, 11.4 miles. This resulted in the improvement in navigable reaches, but no extention of the limits of navigation. The rivers and harbors bill of Aug., 18, 1894 started a seperate project, providing for two locks and dams - one, No. 1, just above the mouth of Minnehaha creek and 3.68 miles above the Minnesota river, (present site of high dam), to have a lift of 13.3 feet; the other, No. 2, 2.88 miles above No. 1, and 2.18 miles below the Washington Avenue bridge to have a lift of 13.8 feet. Lock chambers to be 80 feet by 334 feet and depth on the lower miter sills to be five feet at low water.

1899, March 3 - Rivers and harbors act authorizing completion of lock and dam number 2 and construction of lock and dam number 1, total cost for both locks and dams to be $1,166,457.

1905, March 3 - Rivers and harbors act modified project by requiring channel depth of six feet instead of five. This involved an increase in the lift of the two dams and an increase in the depth on the lower miter sill of Lock number 1 to six feet at low water.

1907, May - Lock and dam Number 2 completed and placed in operation. The masonry of Lock number 1 has been completed, but no work was done on Dam number 1.

1907, Sept., - Commission appoined by Congress to examine and report on the use by the United States, of waters of the Mississippi flowing over dams between St. Paul and Minneapolis, recommended that no power development whatever be attempted at the present at either locks and dams number 1 or number 2.

1909, June 25 - Project further modified by rivers and harbors act, providing for a lift of 30 feet at lock and dam number 1, a depth of 9.5 feet at Washington Avenue bridge, abandonment of lock and dam number 2, and the development of power at number 1. Increased cost estimated at that time at $635,000, but proved to be

1910, - August - Work on the new project started with the dynamiting of Lock and Dam No. 2---a loss of approximately $1,000,000.

eapolis, attended by Mayor Haynes, Mayor Keller of St. Paul, former Governor John Lind, representing the University of Minnesota; Frank J. Watrous, representing the St. Paul Commercial Club; W.P. Roberts,

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1910, Oct 7 - Meeting on the subject of the power to be developed at the high dam, held in the office of Mayor Haynes of Minneapolis, attended by Mayor Haynes, Mayor Keller of St. Paul, former Governor John Lind, representing the University of Minnesota; Frank J. Watrous, representing the St. Paul Commercial Club; W.P. Roberts,

representing the Minneapolis Commercial Club; Representatives Fred Stevens and Frank Nye. Voted that authority should be obtained from the State Legislature to form a corporation to take over and utilize the power at the high dam, supplying the United States government and the University of Minnesota with the power required by each and dividing the remainder equally between St. Paul and Minneapolis.

1910 December 14 - Representative Stevens and Nye requested by War Department to present plan for utilization of power.

1911, February 28 - Senator Fosseen of Hennepin county introduced bill in the state legislature authorizing St. Paul, Minneapolis and the university of Minnesota to form a corporation to handle the power at the high dam.

1911, April 11 - Fosseen bill passed by the legislature.

1911 - Municipal Electric corporation organized under authority of Fosseen, by mayors of St. Paul and Minneapolis and the president of board of regents of the university of Minnesota.

1912, December 3 - Representative Stevens introduced bill in Congress directing Secretary of War to enter into agreement with Municipal Electric corporation, the corporation to pay the government for the use of the high dam power a proportionate maintenance sum, also 3 percent a year on the government's original investment in the dam, the power to be sold to the government for its requirements at Fort Snelling and the Soldiers home, on the same basis as to state institutions.

1913, February - Amendment by Senator Nelson to the rivers and harbors act under consideration in Congress, providing that the Municipal Electric corporation pay the government 4 percent a year on the additional cost of increasing the height of the dam.

1913 - Stevens bill withdrawn in Congress on account of opposition.

1913 - City engineer Claussen of St. Paul estimated power available at the high dam at 15,000 horsepower, with a supplemental investment by St. Paul, Minneapolis and the state university of $350,000, to include a 45,000 horsepower steam plant to act as an auxiliary in times of low water.

1914 - Lock and dam number 1, reported nearing completion. High water broke sluiceways and tore out lower of two coffer dams at number 1, undermining three end sections.

1915, November 29 - Minneapolis Park board, in deeding flowage rights to government, stated "The city desires that the Municipal Electric company shall secure the power and that the government pay nothing. We must respectfully and earnestly urge in behalf of the city of Minneapolis that the government make a grant which shall be acceptable to the Municipal Electric Company.

1915 - High dam again damaged by flood water. Questions of cost, rates and flowage actively debated between two cities and

government.

1917 - High dam finally completed, with 30 feet lift; cost approximately $2,000,000.

1917 - 1922 - Five state legislature met and adjourned without authorizing Municipal Electric corporation to go ahead, the corporation being without legislative premission to finance power project. Bill introduced by Senator Palmer authorizing Municipal Electric corporation to issue bonds died in committee. State attorney general delivered opinion that Municipal Electric corporation, being without power to finance, was automatically defunct.

1921 - Greater St. Paul Committee, as a result of Surveys to determine exact power available and expenses incident to municipal use, came to conclusion that use of power was not practicable for municipal purposes and originated plan to use it industrially.

1921, July - Greater St. Paul Committee files application with Federal Power commission, Washington, for preliminary permit to establish power plant at high dam, and use the power for industrial purposes. This was the first application made to the Federal Power commission.

1921 - Northern States Power Company filed similar application 15 days after St. Paul.

1921,October - Federal Power commission held hearings in St. Paul on applications. St. Paul was found to have offered 100 percent utilization of the available power, Northern States Power Company 100 percent and the city of Minneapoils about 30 percent.

1922, Jan.,16 - In their report of Jan., 16, 1922 the commission says, "In view of its opinion that the people of the two municipalities should be the principal beneficiaries from the large savings that would result from the development of this power, the commission considers that it is, in large measure, the duty as well as the right of these municipalities to reach a mutual agreement upon the manner in which the power may best be developed and used for their benefit. The commission has decided, therefore, to defer action for the present, in the hope that such an agreement may be reached and that a program for using this power, which will be satisfactory to both municipalities, will be presented for its further consideration."

1922, Jan., 16 - Federal Power commission heard arguments in Washington, session attended by Arthur C. Nelson corporation counsel; Aldolph Meyers, consulting engineer; M. M. Cochran of the Greater St. Paul Committee and Representative Keller all from St. Paul. From Minneapolis there were Mayor Leach and Neil Cronin, city attorney, supported by Senator Nelson and Representative Newton. Northern States Power Company represented by Robert F. Pack and Francis Shenehon. Power commission seemed on point of granting application of Northern States Power company, in whose favor the commission engineer reported.

1922, January 24 - In deference to Senator Nelson's and Mayor Leach's pleas for time, to give the Municipal Electric corporation one more chance to see if the two cities could not be brought into agreement, the Federal Power Commission gave a temporary decision, holding the whole matter in abeyance until it could be determined whether St. Paul and Minneapolis could agree on a common plan.

1922 Spring - Colonel L. H. Brittin visited Detroit for the purpose of getting Ford to take over the Overland building. Ford declined with the statement that he could build his own building, but asked if there was any water power to be had.

1922, June 26 - Henry Ford expressed willingness to undertake development of power at the high dam and establish a large manufacturing plant in the Twin Cities.

1922, June 26 - Ford told Minneapolis delegation that he absolutely would not file for the power rights at the high dam unless he was requested to do so jointly by the cities St. Paul and Minneapolis.

1922 Summer - Arguments between the two cities as to Ford proposition. St. Paul favorable, Minneapolis faction headed by Mayor Leach opposed, Mayor Leach holding out for equal division of power between the two cities and use it for municipal purposes.

1922, November 21 - At meeting between St. Paul and Minneapolis representatives, including Mayors Leach and Nelson, St. Paul showed that Mayor Leach's plan to bond Minneapolis for $40,000,000 to effect an annual saving of possibly $40,000 amounts to one percent on a $40,000,000 borrow and was therefore not sound business; also that a municipality could not make economical use for municipal purposes of the relatively small amount of power that would be its share when the power from the high dam was halved. The Minneapolis representaitves voted to join St. Paul in an application for power to be divided equally and used for industrial purposes. Minneapolis introduced the proviso, however, that if the Ford proposition were to be considered at all by Minneapolis, the Ford plant would have to be located half in each city.

1922, November 21 - 27 St. Paul asked Minneapolis to join in application for the power rights, the Ford Motor Company to develop it and select its own site anywhere in the Twin Cities.

1922, November 27 - Minneapolis rejected St. Paul's offer, counter offering to agree on any plan whereby Minneapolis could get its 50 percent of the power.

1922, December 6 - Ford Company filed its own application with the Federal Power Commission in Washington for power rights at the high dam.

1922 December 15 - Minneapolis pledged itself to co-operate with the city of St. Paul in the matter of securing the power rights at the high dam, upon any basis that would insure to Minneapolis the control and use of 50 percent of the power available.

. 1922 December 21-22 - Mayors Nelson and Leach met in inter-city debate uopn question of the high dam.

not complete.

J Russell

S.N.

MISSISSIPPI RIVER PROJECT

(Minneapolis Water Power)

The water power development at Minneapolis is so different in form from the usual development as made today, that it might be of interest to tell its story.

This city of enormous commercial wealth owes its beginning and early development primarily to the great waterpower afforded by the falls of St. Anthony which was, for many years the greatest of utilized water powers in the United States, and which up to 1880 furnished practically all the power used for manufacturing in the city. The total falls utilized by this power is approximately 70 feet and there is a total installed capacity in water wheels of approximately 55,000 horsepower.

The original development which was made at the upper falls utilized a maximum of 50 feet head and developed at times 40,000 horsepower. The other 20 feet of head were used at the lower dam where a maximum of 10,000 horsepower were developed.

The mean flow of the river at this point is about 6,000 second feet with a maximum approximately 60,000 second feet and an extreme low flow of 700 second feet. For navigation purposes it is a partiallly regulated stream, the regulation being provided by means of Government owned and operated reservoirs at the head waters. These reservoirs have a combined capacity of 96 billion cubic feet and store water in wet

seasons for discharge during the navigation season, being used then to maintain a 3-feet gage at St. Paul, 6-foot channel, which means approximately 6,000 second feet flow.

While these reservoirs are maintained primarily as an aid to navigation and absolutely without intentional benefit to the water powers on the river below their outlet, yet there is of course an indirect benefit during the low water period of the summer to all these powers where the increased flow due to to them, can be utilized.

The Mississippi River in its course from Pokegama Dam to St. Paul, has a fall of approximately 482 feet, naerly all of which may in time be used for water power development. In 1880 when the Water Power Census of the United States was prepared, there was only one power development throughout this entire length, namely that at Minneapolis, whereas today there are many developments along the river.

The largest concentrated fall in this stretch of river is at Minneapolis, where after flowing for several hundred miles in a channel cut, for the greater part through glacial drift which covers that region, it breaks through the limestone ledge and leaves the general prairie level for a channel between banks of limestone and sandrock, whose picturesque bluffs define its course below St. Anthony Falls.

These bluffs which mark the channel from St. Anthony Falls, and its juncture with the Minnesota River, are the result of a gradual recession of the crest of the falls which geologists tell us, took centuries to reach the present position.

For several hundred feet above this crest, the water flows over a limestone ledge, which at its lower end is about 16 feet in thickness. This ledge is underlain by the St. Peter sandrock approximately 160 feet thick at this point. The original crest, as stated was probably in the neighborhood of Fort Snelling and has gradually receded to its present location. The water falling over the edge of limestone wore the soft sandrock beneath, undermining and wearing away this support until the limestone would break away in large blocks, always preserving a vertical face to the falls.

In 1868 the recession had become so serious as to threaten their ultimate destruction, for by that time it had approached to within 1,200 feet of the point at which the ledge feathers out to a thin ledge and ceases entirely. It was then feared that the river would possibly cut under the limestone covering and wear away the soft rock below until nothing but the rapids would be left. To prevent this catastrophe a large timber apron was constructed and is still maintained, which has effectually preserved the falls to the present time.

Further protective measures were deemed advisable and upon recommendation of a board of engineers appointed for this purpose, a concrete dyke or wall extending from one bank to the other under the ledge near its lower end was built in 1874. This dyke is a solid wall of concrete in contact at the top with the lower face of the limestone and extending into the sandrock a depth of 38 feet, and has a length of about 1,900 feet from end to end. This work together with the timber protecting apron previously mentioned was done by United States Government Engineers under acts of Congress appropriating money for these purposes.

In the early days no attempt was made to utilize the full fall available, but only that portion between the crest of the dam and the top of the ledge upon which the dam rested. Later shallow tunnels were excavated and the water discharge through the ledge into them, thus realizing a greater head, and ultimately these tunnels were further excavated to their full depth so that now a maximum of 50 feet head is realized.

In 1776 Jonathan Carver, a native of Connecticut, visited the present site of Minneapolis and was probably the first man to appreciate the beautiful Falls of St. Anthony as a prospective water development and nucleus for a settlement. It was not however, until 1821 that any use was made of this power for manufacturing purposes.

The Government had established in 1821 or thereabouts a military post at Fort Snelling and for its own use erected a small saw-mill below the crest of St. Anthony Falls, connecting therewith by means of a wooden flume. This mill constituted the first improvement for power purposes at this place and was in fact the first edifice erected on the site of the present city of Minneapolis, and was the beginning of a development which in later years became the boss of the manufacturing and commercial strength of the city.

At that time the waters tumbled over a limestone ledge and rapids below, between heavily-wooded banks, fifteen hundred feet apart, unrestrained by works of man, whereas today we find the free channel restricted to about five hundred feet in width and the limestone ledge at the crest covered by dams and apron, which control and direct the energy of the river for waterpower purposes.

J Russell

MISSISSIPPI RIVER PROJECT

(Minneapolis Water Power)

In giving a history of the milling interests of Minneapolis, it will be necessary to give a sketch of the changes the falls have themselves undergone since their first discovery.

The strata of rock forming the bed of the river was superimposed upon white sandstone of a very friable nature. From this cause the recession proceeded rapidly by the combined action of frost and water, for the erosion destroyed the sandstone substratum, and the action of the frost and water combined broke down the rock bed of the river. Still another destructive force was added, namely the hand of man in attempting to make more power available. The value of a waterfall consists as much in its availability as in volume and height, and in these respects the Falls of St. Anthony excel, owing to the high banks on each side of the river above the falls, through which sluices were cut, conducting the water to flumes or canals parallel with the main channel. Besides the water power companies, by dams built for the advantage of mills situated on each bank, which forced the flood of the river to about one-third the natural width of the stream and thus hastened the disintegration. The work of destruction by these variuos causes continued silently but nevertheless with alarming rapidity. The attention of the citizens was occasionally called to the danger when undermining process caused an unusual recession, as in 1851, when several rods, ninety feet by actual measurement, of the superstratum fell in one huge mass into the foaming water. It will be interesting to many to find here a record of the axact location of the crest of the fall in 1850.

A line running south 50 degrees west from the north-west corner of the "Pillsbury A" mill, would strike the bend in the crest of the falls, as it was in 1850, about 250 feet west of its eastern end at the old frame saw-mill, and would follow its crest to a point on the west side, nine feet above the lower corner of the Minneapolis Mill, of Crocker, Fisk and Company. The data are obtained from records made and preserved by C. W. Christmas. Persons interested, by standing at the corner of the Pillsbury A mill can easily follow this line and mark the recession of the falls during the thirty years which have elasped sinee the record was made.

Dr. S. H. Chute. in 1864, excavated a tunnel eight feet in diameter, beginning just below the Chalybeate springs, through the soft sand rock about two hundred feet in a straight line, thence parallel with the river to the fall, for a tail race, in order to secure a greater head in utilizing the power. Into this subterranean channel, it was supposed, after encasing it with masonry or sheet iron, the waste water from many mills could be conducted. The work was never completed, but the eroding tooth was by this means, admitted to cut more rapidly at the very vitals of power. This excavation was called Chute's cave, and visitors at the falls were invited to explore its dark regions in a boat kept there for the purpose by persons interseted in a place of resort near the spring. The attractions here were the mineral water, which still continues to flow in great abundance from fissures in the rock, a fish pond and a few curiosities of the animal kingdom. The view of the falls with these extraordinary inducements

rewarded the tourist for the fatigue of descending the long stairway to the bed of the river, and the patronage of the swing, boat and restaurant compensated the enterprising owner. The springs continued to furnish medicinal water, but the remainder gave place during the winter of 1880, to progressive enterprise of mill building. During the same winter occurred the breaking down of the limestone ledge above the tunnel. Into this hole, tumbled a part of Main street. A tree was swalloed up to the limbs, and the corner of a mill standing near, settled to an alarming extent. The danger was near the large and expensive Pillsbury A, mill, but fortunately its foundations were secure.

Still another and most dangerous tunnel, was the excavation on Hennepin Island, begun in 1868 by W.W. Eastman and others, at the foot of Hennepin Island, and intended to extend under the island and under the river to Nicollet Island, where the manufacturing establishments were to be located. Before the work approached completion, and while it was progressing under the river above the island, dangerous percolation began which continued through new and enlarged apertures, but the alarm did not discontinue the work until the laborers were driven out by the rapidly increasing torrent, by which one of their number was swept away into the torrent below and narrowly escaped drowning, while the remainder hurried out by a perpendicular shaft that had been sunk at the head of Hennepin Island.

The power of the falls was thus turned to their own destruction; the sides of the tunnel dropped in and down went the rocks forming the river's bed, with logs and debris in a tangled mass. The alarm was given "The falls are going out" and the citizens as well as proprietors joined in the effort to stay the destruction. The alarm was well grounded, for the rock bed of the river only extended twelve hundred feet above the falls, having at the time of settlement of St. Anthony cut its way nearly through the limestone layer. The temporary expedients resorted to were continued, renewed and changed, until by an appropriation from the national government, municipal aid and private contribuation, elaborate plans were carried out for permanent preservation of the falls. The companies controlling the water power made, in 1866, an attempt to protect the crest of the falls by a timber apron, but this was carried off in the following spring.

A survey, made in 1869, by Major G.K.Warren, called the attention of the general government to the necessity of arresting their destruction. James B Francis, of Massashusetts, was summoned to examine the falls and report as to the best means of averting the catastrophe. He recommended as a protection against the recession of the crest, a substantial apron of timber with heavy crib-work at the bottom; for the dangerous tunnel, that it be filled for four hundred feet with a puddle of clay and gravel; againt the third danger, the action of frost, that the limestone be kept flooded by low dams.

No time was lost in carring out energetic measures. A "Board of Construction," appointed by the citizens, set about building the apron, and private enterprise and government aid, united in the work. Government approriations amounting to $555,000 were made, beginning in 1870 and ending with that of March 3rd, 1879. A contrete wall was laid in the bed of sandstone, beneath the limestone ledge, six feet in thickness at the base and four feet at the top, and forty feet in height, extending entirely across the river, thus effectually preventing and further leakage. The amount contributed by the citizens of Minneapolis toward the preservation of the falls was $334,500. The whole cost of the improvement thus buried out of sight, was nearly a million dollars, but from it came the preservation of thefalls with its one hundred and twenty thousand horse-power and the future hope of Minneapolis.

History of Hennepin County and outlines of the History of Minnesota. North Star Publishing Company. 1881.

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FAW

J. Russell

MISSISSIPPI RIVER PROJECT

(Twin City Power Stations)

Commercial lighting and power are supplied in the Twin Cities by the Northern States Power and Light Company, which is under Byllesby control. Within a radius of seventy-five miles, a number of water-power plants carry the load up to their capacity limits, and the balance is cared for by steam plants belonging to the company.

For Minneapolis, Riverside Station is the steam station stand-by plant. It has been remodeled recently and now contains two 6,000 and one 1,500 kilowatt horizontal turbo-generators, all served by individual condencers. For the smaller units the condenser auxilieries are steam driven, while those of the larger turbines are driven by motor, with the exception of the dry-vacuum pump, which is of the two stage, one cylinder type. An air washer cools and cleans the air for the large generators. Three-phase 60 cycle current is generated at 2,300 and 13,200 volts.

Steam is supplied by 12,300 horsepower water tube boilers at 200 ponnd pressure and 125 degrees of superheat. The stikers are of the underfeed type, with seven retorts per boiler, the blast fans being driven by geared turbines. Steam is kept up at all times, so that the atation may take the load instantly. During certain hours of the day, the generators are motored that is, run as synchronous motors for the system voltage regulation.

They operated in the same way during threatening weather, so that if lightening or other troubles should interrupt the service, the load may be instantly taken by the turbines. At such times a small amount of steam is fed around the throttle through a one quarter inch pipe into the turbine to keep the balding cool. This may sound parodoxical, but experience has shown that the steam prevents overheating and eliminates operating difficulties.

The company has a similar plant at St. Paul, containing two 1,000, and one 2,000, and one 4,000 kilowatt horizontal turbo-generators. The machine are motored in the same way at as Riverside, so that this station is also ready for instant service should the occassion arise.

In winter the plant carries a large load and the electrical energy generated is limited to that which the heating steam will supply. Water-tube boilers to a capacity of 5,600 horsepower are installed and served by underfeed five-retort stokers.

One of the water plants is situated in the heart of Minneapolis, at St. Anthony Falls. It contains three units aggregating 2,000 kilowatts under a maximum head of 42 feet. A feature not common inthe late days, inthe employment of the rope drives between waterwheels and generators. This plant is the principal distriubting station of the Minneapolis system, all current being received and dis-

Of the various water-power plants operated by the company, the development at Coon Rapids is the latest and is one of the most modern hydrulic installations in the country. The plant is only eleven miles north of Minneapolis. The equipment consists of 5 - 2,100 horsepower vertical single runner water wheel operating under an average haed of 17.5 feet, at 62 revolutions per minute, each wheel being directly connected at a three phase 60 cycle 2,300 generator.

The dam is over 2000 feet long, and is equipped with large Tainter gates. A feature is the provision of a permanent individual hoist for each gate. They are arranged for operation either by habd or motor, the latter being mounted on a truck traveling on rails along the dam.

As much power as possible is obtained from the water plants, the balance being carried by the steam stations, which is a full reserve plant, acpable of carrying the entire load.

One of the most interesting features in the plaht is the German engine, which was built by F. Schachau, of Elbing Prussia. It was exhibited at the Chicago World's Fair, and was purchased by the Washburn-Crosby Company at that time. It has cylinders 28,38, and 56 inches in diameter, a stroke of 29 inches and a speed of 110 revolutions per minute. The only casting on the engine are the foun-

ation plate and the cylinder. The former is 18 feet long and nine feet wide weighing twenty-three tons. It was cast in one piece. The steel frame is light, but strong and accessible. The high pressure cylinder has a main piston valve, and a rider cutoff valve located inside the piston valve, and operated by a seperate eccentric. Both the intermediate and the low-pressure cylinders have balanced slide valves. On top of the valve cheat each of these cylinders is a small steam cylinder, into which the valve stem extends. carying on the end a piston.

Steam from the intermediate receiver acts underneeth the piston to support the weight of the valve stem, valve eccentric rod and strap.

Another interesting feature is the use of a loose brass ring between the eccentric and the strap. This divides the wear so that it has been necessary to take up one eccentric a very little only once in the twenty-three years the engine has been in operation.

Although the engine is of a vertical type, the piston had tailrods with castings having spirial grooves. With this construction the wear is evenly distributed and the steam has excess to the top of the tailrod, so that the full area of the piston is effective. The high presseure and intermediate cylinders are steam-jacketed, and the air pump, which is driven from the intermediate cross head, has very little clearance, so that the average vacuum of 28 inches is in a jet condenser is readily obtainable.

Another interesting engine is a horizontal four cylinder triple-expension unit of American make. The cylinders are arranged two in t tendem, one high, and one low pressure cylinder on side and intermediate and other low pressure on the other.

If need be, the side containing the high pressure cylinder may be operated independently. The engime is of the heavy duty Corliss type, rated at 2,600 horsepower, although at times is carries over 3,000 horsepower. It is connected to the mill by a rope drive. The cylinders are 24, 46 and 48 inches in diameter, and the low pressure cylinders being the same size, and the stroke is 48 inches. The speed is 104 revolutions per minute. The valves are partly located in the cylinder head to reduce the clearance. On the intermediate and both low-pressure cylinders they are operated directly from the rocker arms, without wristplates. Both intermediate and low-pressure receivers contain superheating coils through which live steam passes. The steam consumption per indicated horsepower is about 12 pounds.. Including the shaft, flywheel and receivers, the engins weighs 200 tons.

1/6/38

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Russell

Week of April 14, 1938

MISSISSIPPI RIVER PROJECT

Water Power On Miss., River)

A use of water is its capacity to generate energy and thereby produce light heat and power. The inventory of our water resources has not yet been completed, but the U S Geological Survey, in its report an water resources in Minnesota, published in the report of the state drainage commission for the year 1910, shows a total water power possibility, thus far installed in the state of 185,115, theoretical horsepower, but an average horsepower of 113,655. The undeveloped horsepower approximately estimated at over 440,000.

For the purpose of this report the water powers shall be treated as 100,000 horsepower developed, although it exceeds this amount and 500,000 horsepower undeveloped, this amount will probably be exceeded, and possibly almost doubled.

Some of the authorities or writers, in discussing the value of water power compare it with coal, or in other words, they take the cost of a horsepower developed from water and compare it with the cost of a horsepower by steam from coal. There are many questions to be considered in every comparison of this kind. Each comparison should be based on the facts that enter into the equation.

No general statement could be truthfully and fairly be made covering a whole state, but the use of number of compairsons, with the fact in each case, will enable one to reach a resonable fair conclusion in comparing the cost of water power and steam power.

A board of United States Army engineers in their report to the war department made the following compairsons between water and steam power as Minneapolis, and on the river between Pahegama Dam and the Twin Cities:

The amount of capitol directly interested in manufacturing plants between St. Paul and Pahegama Dam which use the river as their principal source of power may be stated conservatively as from $13,000,000 to $15,000,000. But even these large figures do not convey a fair idea of the importance to the community of the water power. To very large extent the industrial development of Minneapolis is due to them, directly or inderectly, and Minneapolis, representing a wealth more than $260,000,000, produces about $170,000,000 worth of manufactured products annually.

The power of the turbines at Minneapolis alone is about 43,000 horsepower, although this cannot be continuously developed and must be supplemented a part of the time by steam.

The mills that utilize water power primarily produce more than 16,000,000 barrels of flour a year. Using water power, flour can be ground for less than 1 cent per barrel, while the cost of producing one barrel by steam is more than five times as great. The average cost per horsepower per annum using steam with fair economy and with the cost of coal as it is Minneapolis, is about $42. The average rental of water power per horsepower per annum at Minneapolis is less than six dollars.

It is a fair statment to estimate the further power power that will in the near future, be developed between Pahegama and St. Paul at 70,000 horsepower, and utlimately this will undaubtedly be increased to 100,000 horsepower. It is not extravagant to estimate the direct annual value of the resevouir system as at present operated to present and prospective mill interests at $500,000. Undaubtedly a large proportion of this benefit is conferred upon the general public. indirect benefits to local communnities, due to industries developed by these water powers, one unquestionably great, but are not character that can be estimated in definite figures.

This gives a preference at Minneapolis in the cost by water as compared with coal at $36 per horsepower per annum.

It is only fair to say in explanation that this low of $6, per horsepower, was made at an early day on long-time contracts, but more recent contracts fix a higher price per horsepower.

At Duluth the price is $26 per horsepower per annum but surplus power at hours when the peak load is off can be bought at a much lower figure, in some cases as low as $10 per horsepower.

John H. Lewis, state engineer of oregon, in a paper addressed to the governor of that state said that many people do not realize the actual laten value of water in running streams, when viewed from a commercial standpoint.

At Los Angles, where the city has issued bonds to the amount of $23,000,000, to produce a supply of water from Owens River, they have also organized a power development company to utilize the power sites along the line of their water canal, and they estimate the income from the power company will provide sufficient revenue to pay all fixed charges and provide a sinking fund that will pay the bonds off in thirty years time.

Now if there ia an actual saving between the cost of a horsepower made by water power over a horsepower made by steam of, say $15 per horsepower per year, there in the 100,000 horsepower undeveloped we would save annually $7,250,000, or a total

saving by using 600,000 horsepower developed from our water resources of $9,000,000 annually.

By developing and utilizing the undeveloped horsepower to 500,000 horsepower enough energy could be generated to light 7,600,000-16-candlepower lamps.

This undeveloped power could also produce heat equivalent to that produced by 2,900,00 tons of coal.

These figures are not given as absolutely correct because hypothetical question and answer involves so many conditions that it is not fair to state a part without stating and considering the whole.

The statements are only designed to show the great value of an asset owned by the state, but as yet comparatively unprotected and but little appreciated. Of course it will be many years before all of this water is developed. The development will come only as required by commercial demand.

It is like iron in the mine or money in the bank. It is here to be drawn upon as the develops and in accordance with the commercial necessities of a highly progressive people.

It should also be borne in mind that the coal resources of the country are rapidly being depleted and utilization of water power is conservation of the coal measures of the country.

The water resources of Minnesota are a heritage to all of the people and they have a value of several millions of dollars annually. They are being steadily absorbed and taken up by large and strong corporations without any protest from the people and without the state having that control which is, should exercise and retain in the interest of the people.

When coal measures are mined and burned, they are not replaced. The water power resources of Minnesota are a continous performance, that will go on forever, as far as we know. A six or eight million dollar proposition that reproduces itself annually is a natural resource, worthy of the best thought and brain of the legislature.

There can be no question as to ownership of all the waters of the state by the people. The question as to its development uses and control of these waters in the interest of the people. In those states where these questions have received the most careful consideration, the tendency is not only to retain the control, but to develop to the expense of the state, and operate them as public utilities. This could be done in Minnesota without a constitutional amendment.

The northern part of Minnesota is rich in water as well as in other resources. Facilities for travel and interchange of commodities is one of the crying necissities of this region. In time electric roads will be built, factories established, and all

the accessaries of a high civilization, will require every horse-power that can be developed for use in this region. Transportation by this means can be furnished to every community when it develops up to a point justifying railroad facilities. Electric lines in time should reach all well settled communities.

No better measure could be adopted than a policy of holding and developing these natural resources in the interest of the localities where they are situated. They should not be permitted to fall into the ownership and control of monoply, except as charges are regulated by the state in the interest of the people. The control, preservation and distribution of the important problems of conservation in the state.

From the First Annual Report of the Waterways Commission of Minnesota, December 31, 1910. Clo., James H. Davidson, Chairman.

J. Russell

Rud/L.V.

MISSISSIPPI RIVER PROJECT

(Story Water Power Development at High Dam)

The fight kept on between the two cities for the location of the Ford Motor Company's plant. In the first place the Minneapolis Civic and Commerce Association and the business men of Minneapolis had been sympathetic to the establishment of a Ford plant in the Northwest. With the general understanding that the Ford interests were to be enlarged in this territory, the Association was anxious to have the development take place in Minneapolis, or next best, in a place that would bring to the city maximum benefits.

At the that time there was a large Ford assembling plant located in Minneapolis. This was of value to the city. An enlargement of the Ford interests in the Northwest, if built in or adjacent to Minneapolis, they felt, would mean the amalgamation of the Minneapolis assembling plant with the new industry. If the proposed plant were not built in Minneapolis it might mean a distinct loss to the city. Here, therefore, entered one element of consideration.

It had long been the policy of the Ford Company to acquire industrial sites adjacent to water power. Knowing this, the organizations of St. Paul conceived the idea of presenting to Mr. Ford the possibilities of acquiring a site adjacent to the high dam in the Mississippi River on the St. Paul side and pledged their influence to secure for the Ford Project the water power created by the dam. However, by legislative action

the development of the water power had been given jointly to the cities of Minneapolis and St. Paul and to the State University. Therefore, St Paul's pledge to Mr. Ford could not be executed singlehanded. From the beginning of negotiations on the whole matter of water power at the the dam had been considered the crux of the situation.

It was impossible for the city of Minneapolis and organizations interested in it to counter the offer of St. Paul by proposal of any site on the Minneapolis side of the river as Minnehaha Park occupies the area west of the dam. No such site existed within the city limits.

The Board of Directors of the Association, assisted by business interests and important civic and commercial organizations, worked faithfully to safeguard the city's interests. After much deliberation three distinct phases of the situation presented themselves. A summary of the three points follow:

1 - Months before, the city of St. Paul applied for the exclusive use of the water power at the high dam and in support of its claim filed a brief showing a proposed industrial development in the district adjacent to the power dam. It soon developed that if St. Paul were successful in securing the power rights they were to be turned over to the Ford Motor Company. The Association then went on record as opposed to relinquishing its claim on its share of the power, and started immediately to work on a counter suggestion that it felt would be beneficial to Minneapolis and equally fair to St. Paul.

Representatives of the Association interviewed the Ford Motor Company at Detroit and proposed a plan. This plan involved working with St. Paul to secure the water power rights for the Ford interests, with the understanding that the new industry to be placed on neutral ground outside of both cities and equally adjacent to them, with the suggestion that this neutral site be the Fort Snelling reservation. It was thought this might be obtained from the government for industrial purposes if there was a unanimity of sentiment in both cities for its acquisition. Two difficulties presented themselves in the successful carrying out of the negotiations on this basis. The first and most important of these was the fact that Mr. Ford was unwilling to transmit the power from the high dam, which would have been necessary had the Fort Snelling site been selected. In the second place the city of St. Paul felt this scheme was impractical on the basis that it would be difficult to acquire from the government the Fort Snelling reservation for industrial purposes and the relinquishment of it as a military post. Whether or not this constituted a valid reason is relatively unimportant. The essential fact was that the proposition was not acceptable to St. Paul and impossible of fulfilment unless that city was willing to join with Minneapolis.

2 - The next basis of negotiations was similar to the first. St. Paul suggested acquiring a neutral site for the Ford plant north of the State Fair grounds. This involved the transmission of the electric power to that site in about the same way as suggested in the previous phases of negotiations. The proposition was looked upon with some mutual favor in both cities. Unfortunately it had its objections. In the first place it was discovered that Mr. Ford was especially anxious to acquire an

industrial site in the Twin Cities because it held the possibilities of of developing river transportation, which the Ford Motor Company considered of great potential value. Consequently they were unwilling to locate their plant on any site other than one immediately adjacent to the river. In the second place, this proposed tract north of the State Fair grounds involved again the transmission of the power which the Ford Company was unwilling to undertake. Therefore, this proposal also failed, and the Minneapolis Civic and Commerce Association proceeded to a more serious consideration of the St. Paul proposition.

3 - In breif, the city of St.Paul invited the Ford Motor Company to locate a branch plant on the new industrial tract adjacent to the high dam and pledged its support to secure for the company the water power rights. They also requested Minneapolis to join with them in this proposition, and argued that the Ford enterprise would be valuable to both cities, in that it might employ from 10,000 to 14,000 men. It was at once recognozed by Minneapolis that this proposal would probably mean the amalgamation of the assembling plant then located in Minneapolis with the new plant. Minneapolis felt that this would mean an achievement by St. Paul of securing an important new industry, but they also realized that the erection of necessary bridges and transportation facilities would mean a benefit to Minneapolis, in that a large number of Minneapolis people would be available for employment in the new plant. They further felt that this location would mean an unusually rapid development of the south side of the city as a residential district for the workers and possibly certain sections of it as industrial district for accessory plants.

During the time these negotiations were in process the public was given the impression that the Minneapolis Civic and Commerce Association was not functioning. The sentiment of the city seemed to be reflected in the attitude of Mayor Leach, who had consistently maintained the position that Minneapolis should insist upon the retention of the water power rights to develop electricity for municipal purposes, especially for street illumination and for the more fundamental purpose of maintaining a check upon the public service corporation that had a monopoly in furnishing electricity. The Minneapolis Civic and Commerce Association had never endorsed the Mayor's position nor taken any action with respect to it.

It is obvious why it was impossible for the Association to explain itself publicly at that time. It could not consistently approve the mayor's plan and at the same time continue negotiations with the Ford interests. It could not disapprove the mayor's plan without a full statement as to the reasons for its action. It was absloutely impossible to give any reasons for disapproving the plan without calling public attention to the nature of its confidential and independent negotiations.

In light of the foregoing statement the directors of the Minneapolis Civic and Commerce Association at a meeting held Saturday January 13, 1923, took the following action:

WHEREAS the Ford Motor Company has definitely decided on the location of the High Dam on the Mississippi River, lying between the cities of Minneapolis and St. Paul and has shown its good faith by outright purchase of the necessary land, and .....

WHEREAS the size of its proposed industry and its importance to the Twin Cities and to the entire northwest appears to be dependent on the extent to which the Ford Motor Company is able to utilize the water power at said location, and

WHEREAS the City of St. Paul through its business interests as represented by the Excutive Committee of the St. Paul Association and the greater St. Paul Committee has pledged itself to share equally with the City of Minneapolis in the cost of constructing a suitable traffic bridge across the Mississipppi at a point convenient to the proposed Ford Plant concident with the construction thereof and has also pledged itself to assist in every way to establish street car connections across said bridge with Minneapolis and

WHEREAS the City Council of the City of St. Paul has shown its interest in this matter by passing a resolution pledging itself to a share in the construction of the said bridge across the Mississippi, which bridge when constructed will make the Ford Plant equally accessible to both cities.

NOW THEREFORE BE IT RESOLVED that the Board of Directors of the Minneapolis Civic and Commerce Association recommend that the City of Minneapolis cooperate with the City of St. Paul to the end that the water power rights at the High Dam may be acquired by the Ford Motor Company.

The decision of the Ford Motor Company has been to construct a plant on the property recently purchased in St. Paul. In the opinion of the Board of Directors of the Association the development of a really gigantic enterprise which would bring value to Minneapolis as well as to St. Paul and might employ as many as 10,000 to 14,000 men, is contingent

upon the acquiring of power rights by the Ford Motor Company. The granting of these rights would be difficult if the city of Minneapolis is not willing to join with St. Paul in the request that the Ford interests be granted the power.

While the Association regrets its inability to secure the Ford plant for Minneapolis, it is forced to recognize that it did not have the benefit of the natural requirements upon which the Ford Motor Company insisted and in the absence of these requirements it now wholeheartedly pledges itself to support St. Paul in the development of this large industry.

1752 words

not complete.

MISSISSIPPI RIVER PROJECT

(Water Power at High Dam, Ford Plant)

With regard to water power development on the Mississippi River, the Electrical World of December 27, 1924 said "the Northern States Power Company is building an 80,000 horsepower plant to be operated by steam, costing $10,000,000, which will have 40,000 horsepower available in June and the remainder in August.

The Ford Motor Company at its Twin City plant at the high dam is completing an 18,000 horsepower plant to be operated by water-power from the high dam at a cost of $2,200,000 and the first of this power will be available in June.

The Ford company has begun construction of a 5,000 horsepower electrical plant, which will cost $800,000 to be operated by steam at its Twin City plant, with provision to enlarge to 10,000 horsepower and this will be finished in the winter.

The St. Paul Gas Light Company is completing a 30,000 electrical horsepower plant to be operated by steam and costing $2,000,000, which will be in production by August 1.

All of the new plants are along the navigable of the Mississippi river and if coal can be brought up the river to these plants, they will be potential customers of the barge lines.

The combined waterpower and steam operated plants making electricity available to the twin cities, including Northern States, St, Paul Gas Light and the Twin City Rapid Transit companies, taking into consideration also the power generated at St, Anthony Falls, will have a capacity of 450,000 horsepower when the 133,000 additional horsepower is developed. Few American industrial centers are as well equipped with power.

Probably 75 per cent of all the power generated by electrical companies operating from headquarters in the twin cities is used in the twin cities. The remaining 25 per cent is distributed in the surrounding territory.

With these new steam plants along the Mississippi river, persons interested in river development pointed out that stimulus given to river navagation by the Ford Motor Company, which is building a harbor in connection with its twin city plant, and is palning to ship,and receive by river barges, may mean that Franklin county Ill., coal will be used in the plants. A barge line, operated as "floating trains," already is being built for operation between St. Louis and Minneapolis. A demonstration fleet will come up the Mississippi late next summer.

The availability of power for industrial purposes is held to be an important factor in developing an industrial center. The increase in the electrical power available, is expected to continue what utility company officials said is a "cheap power center." They pointed out that the average cost of electircity today is lower than it was in 1913. The average increase in the cost of all electricity

used in this center, as comapred with 1917, whic was the low period just before the war, is 12 per cent, they said records show, while the price of coal has increased 100 per cent. This year 57.3 per cent of all electricity used is produced by steam as compared with 14 per cent in 1914. Now the district is using 90 per cent of steam produced electricity because of the low stage of the water while the average for the year is about 57.3 per cent. All the water power available in this section has been developed by the utility companies as a coal conservation measure, and the Northern States Power Company now is making plans to develop another 25,000 horsepower plant along a waterpower.

With the additional 133,000 horsepower, there will be a leeway of about 40, 000 horsepower in this industrial center for industrial expansion, utility company officials said.

The Northern States Power Company now is completing a power loop around the twin cities, with the steam produced electricity furnished from within the loop and the waterpower electricity feeding in from the outside. This line can be tapped wherever needed to supply industries.

The installation at the new St. Paul Gas Light company plant, which distributes to St. Paul and South St. Paul, provides for 30,000 horsepower. The plant will be in operation in August. This plant is being equipped with turbines, exceeded in size in only a few plants in the United States, according to W. E King & Day, engineers. This plant is located near the Omaha bridge in St. Paul. The method of generating steam in the plant is unique in this section

Cheap coal is to be pulverized as fine as flour, and this is to blown from four jets under each of four boilers. The gas from this caol will fire the boilers. The building is virtually completed except for installation of equipment.

The plant is being built so that the capacity can be quadrupled within the same structure, with the installation of additional machinery.

When these new power plants are built and in operation this year, the twin cities will offer one of the most strategic points for industry in the United States, according to power producing firms and industrial leaders. The district will have these essentials:"

Nine railraod lines.
The Mississippi river, withassurance of a freight barge service this year.
Adequate and cheap power.
Favorable labor conditions
A vast territory rich in raw materials for manufacture
A great trade territory in which to distribute manufactured good.

S.N.

Russell

MISSISSIPPI RIVER PROJECT

(Story of Power Grant to Ford Motor Co.)

On March 2, 1922 a preliminary permit for the development of power at the High Dam was granted to the Ford Motor Company by the Federal Power Commission. The permit was to run for four months, during which time the Ford Company had to file its application for a license setting forth its plans for the full utilization of the power to be developed and the manner of disposing of any surplus power. A reasonable rental charge was to be fixed by the commission to be paid for the property involved.

It was made plain to the commission that the Northern States Power Company had willingly given up its advantageous position with respect to the granting of the power license, because of the desires of the two cities to have Ford locate his industrial plant in the Twin Cities. It was pointed out that in return for its withdrawal from the field, that it should at least be given the right to any excess power which might be developed. The further argument was offered that the Northern States Power Compnay was the only agency which could utilize such power, coming as it does for a few weeks at a time in the spring and fall and not at all during the summer.

R. F. Pack pointed out to the commission that the Northern States Power Company had the prior application for the power rights at the high dam, which was the only application pending before the commission in January, 1922. He said, however, there was an undoubted sentiment in the Twin Cities in favor of giving the license to Ford. While ready to step aside in behalf of Ford, he said that in the interest of 150,000 customers and 25,000 stockholders his company was obligated to ask some guarantees that excess power would not be turned over to some competitive agency. This excess power, if any, he said should be sold to some established agency able to make full utilization of it and a stipulation to this effect should be inserted into the license. His company, and his company alone, he said was equipped to make use of this surplus power.

W. B. Mayo, chief engineer for the Ford Motor Company, said that the Ford Motor Company ~~begs~~ begged to submit information to supplement its application of December 4, 1922, for permit to install water-wheel, generators and other auxiliary equipment in power house sub-structure then in place at Mississippi River Lock and Dam Number 1, and to use the power which could be produced at the site.

He further said that the applicant had begun the preparation of the plans of the power development and was prepared to proceed at once with the construction of the plant and the installation of all hydro-electric machinery and appurtenances required in connection with this development.

The plans prepared by the Ford Motor Company called for the installation of four units of 4,500 horsepower each or 18,000 horsepower total. The Ford Motor Company had also arranged to proceed with the construction of the plant as soon as the license were granted and plans approved by the Federal Power Commission.

In anticipation of favorable action on their application, the Ford Motor Company had purchased 167 acres of land adjacent to the high dam site for which it paid 315,00 dollars. It also had under negotiation arrangements for reaching the site by suitable railroad connections, and also by street railway connections, through the construction of a bridge between the cities of Minneapolis and St. Paul. These connections would make the site easily accessible to labor in both cities.

The Ford Company had underway plans for the construction of manufacturing and assembling building units. These were to be of first class construction in every respect. They were to be of such number and size as to provide for the installation of manufacuring facilities that will within a reasonable time utilize all the power available at the site.

Engineers of the Ford Motor Company reached the Twin Cities the first week in March 1923, to begin work on the $10,000,000 plant. Their first task was to take measurements and prepare specifications on which contractors were asked to bid.

W. B. Mayo, chief engineer of the company, announced that with the preliminary permit granted and preparations underway to meet the terms laid down by the federal power commission for the grant of a final license, the company hoped to have the first units of its Twin City plant in operation within eight months.

The Ford Motor Company had until July 1, 1923, to meet conditions laid down in the preliminary permit granted by the government to obtain a license. Actual building operations were to began the moment the license was granted.

The Federal Power Commission laid special emphasis on the need for complete utilization of all the energy available at the site. The Ford Motor Company planed to fully utilize all the energy eventually, but in the development period of its industrial project recognized that there would be some surplus power.

The Federal Power Commission required assurance that the surplus power and any other that would become available would be used, and further required submission to it in satisfactory form of an executed contract between the Ford Motor Company and some users of energy providing for the sale, delivery and use of all surplus power not needed for the licensee's own manufacuring operations and to make the necessary interconnections to effect such delivery.

The Ford Motor Company was eager to begin work at the earliest possible date on its industrial development in construction of the power house, and to that end planned to push preparations and the submission of the application to the commission for the formal license to use the power.

Eleven conditions were inposed upon the Ford Motor Company, which had to be included in the application for license: The Ford Company had to present a contract of contracts for the sale of all surplus power. The Ford Company must operate the project works at all times in such a manner as to produce the maximum feasible power, when the machinery was installed. The Ford Motor Company was required to install and maintain suitable facilities for delivering power into the system or systems of one or more of the agencies serving power to the region, and was further required to sell all of the power from the project works could not be profitable used in its own business to agency or agencies.

The Ford Motor Company had to so organize and conduct their business/~~so~~ that the cost of producing power from the project works and the income derived therefrom be clearly determined. The Ford Company had to furnish evidence to the federal power commission that ov erhead or other charges aalocated to the power project were just and proper.

The Ford Company had to assume responsibility for damages due to the overflow if the level of the water at the dam was raised by the company to a greater height than the flowage rights acquired the the United States.

The charge for thedam was to be based on an investment of the United States of $1,193,000 with interest thereon at 5 per cent, depreciation of 1½ per cent, a total charge of $94,455 per annum.

Minor provisions related to payment for inspection; operation of sliding sluice valves; responsibility for the maintenance of the foundation; installation of water gauges and supplying power for the operation of the locks and lighting of the dam inthe interest of navigation.

Under law the commission was charged with the duty of granting licenses to persons or corporations to develop the power to the fullest extent. That was the reason for the requirment that contracts shall be submitted for the sale of surplus power to other agencies. The commission sought to obtain the development of all the power in the requirment that the licenses was to operate the works at all times and in a manner to produce the maximum feasible power.

The provision relating to the conduct of the business in such a manner as to supply evidence to the commission on the cost of producing power and the income is intended to be a check on the grantee. The commission believed that the power plant should be substantial and durable, and that it should be constructed in such a manner as to develop and deliver power at the minimum cost consistent with efficient service.

A requirement that the business shall be conducted in such a manner as would give the commission information regarding the income derived from the power was in accordance with law, which gave the commission control of the rates and supervision of the operation of the plant.

The commission did not take any responsibility for damages caused by raising of the level of the water to a greater height than the flowage rights then acquired by the Federal Government. This clause was placed in the contract for the protection of the United States.

The annual charge for the use of the dam was based upon a total cost of approximately $1,900,000. There was a seperation of the cost for the construction of the dam for navigation purposes and the added construction for the creation of power. It was estimated that the United States invested approximately $1,200,000 for power purposes and the rental charge was fixed upon a 5 per cent return to the United States with an added 3 per cent to cover depreciation and maintenance.

P.V. 3/4.

J Russell

MISSISSIPPI RIVER PROJECT

(Water Power at High Bridge St. Paul)

The first two-unit section of the High Bridge generating station of the Northern States Power Company on the Mississippi River between St. Paul and West St. Paul, which will serve as a base-load plant to supplement the nearby water powers, was completed in 1924. No radical departures were made, economy of operation being balanced against the fixed charges in the design with due regard to simplicity and convenience of operation.

It was decided that the higher cost of providing for the use of pulverized fuel would offset its higher efficiency and flexibility, and for this reason underfeed stokers were used. Two-stage bleeding of turbines, with a fair proportion of steam and dual drives for auxiliaries, has been chosen to insure feed water in excess of 200 degrees at any load. Owing to the silt and sewage in the river, evaporators are being used for boiler make-up water. Because of the multiplicity of the stations tied together by a high-tension loop, around St. Paul and Minneapolis, no duplication in auxiliaries has been provided. Economizers and perheaters and house turbines were omitted from the plan after careful consideration.

Illinois, Indiana or Eastern coals - the latter received

by the Great Lakes water route- can be used in this station, the kind selected at any time depending on the number of B.t. u.'s which can be obtained per dollar. At the time of building of this plant, the basis of comparison favors Eastern coal. Between Duluth (the lake port) and St. Paul the coal was transported by rail, of course, and the double unloading tracks, housed because of the extreme temperatures in the winter, with six hoppers per track, is used for unloading and the coal is transported to the crushers and bunkers by belt conveyors and bucket conveyors. Coal is handled in open storage which accommodates 170,000 tons by locomotive cranes.

Steel-cased boilers to operate at 300 lb. pressure and 672 degrees F. is installed on each side of the firing aisles with bunkers over each aisle. The boilers are of the double-deck type with a total heating surface of 18,750 sq. ft. A large percentage of the lower tubes are exposed to radiant heat. The furnace has a volume of 5,300 cu. ft., or 2.8 cu. ft per 10 sq. ft. of heating surface. A radiant superheater is installed in the bridge wall of each furnace and a convection-type superheater above the tubes between the first and the second passes. The combination is provided to assure a more uniform superheat with varying load. The underfeed stokers with clinkers grinders is divided into two sections, each driven by multispeed induction motors through silent chains. The two halves of each group can be coupled in an emergency and driven by one motor. The forced-draft fans are driven by slipring motors. Hand control is provided at each boiler

panel for two stokers, two fans and two clinker grinders. The air supply ducts can be cross-connected in an emergency. Brick-lined 40-ton ash pits are provided under each furnace with pneumatically controlled gates which discharge directly into railroad cars.

Instead of the usual steam-header system, this plant is equipped with manifolds just long enough to accommodate connections. Motor-operated sectionalizing valves are used. The turbines are of the seventeen-stage Curtis type, guaranteed to operate with a water rate of 9.6 lb. per kilowatt-hour at the most efficient rating, namely, 27,000 kilowatt. These prime movers drive 35,300-kva., 13,200-volt generators, which have seperate exciters with dual drive and a closed system of ventilation with space for air washers under the generators.

Since there is a difference of 20 feet between the high-water and low-water elevation of the Mississippi River at this point, pits have been excavated to a low-water elevation for the condenser auxiliaries, boiler-feed and service pumps are accommodated in the pit and served by either the turbine-room crane or an auxiliary crane. These pits are lined with white glazed tile.

The basement floor is really the main floor of the generating plant, the units being placed on island foundations with merely walkways around them. These arrangements make all piping accessible, avoid heat concentration and facilitate ventilation and

illumination of the plant.

Condensate from the condensers is pumped through the feed-water evaporator condenser. The circulating-water intake and discharge constitutes one part of the plant and was laid out for the first half of the installation, which was eight units. Provision was made for recirculating the water in winter to prevent frazil ice accumulating on the trash racks. Each condenser contains 44,000 sq. ft. of cooling surface and is equipped with a single circulating pump with dual drive.

The switch house has six floors - the first containing the outgoing cables, the second housing the feeder reactors, transformers and automatic starters for exciters; the third accommodating the control conduits, the forth the oil circuit breakeers, the fifth the main and auxiliary 13,200 volt buses, and the sixth floor the bus reactors and bus-tie breakers. One of the features of the electrical part of the plant is the use of copper bars from the generators to the buses and from the buses to the cable end bells, supported in such a way that they are accessible at all points.

No high voltage cable is used inside the station. Truck type circuit breakers are used extensively and are interlocked with disconnecting switches, which are gang operated. Double sectionalized buses with reactors between each two sections are used, with one generator per bus section.

Auxiliary power to the extent of 3,500 kw. connected load is supplied from the main buses through either of the two transformer banks. Motors rated at 75 horsepower or more operate at 2,300 volts, the smaller ones at 220 vlots.

Sources of Information:

Power Sept. 1926
Hill Pub. Co. New York

Electrical World
Dec 1924.

1/6/38

J. Russell

Week of April 14, 1938.

MISSISSIPPI RIVER PROJECT
(Minnesota River)

The Minnesota River rises in the South Dakota Hills, about 402 miles from the point where it enters the Mississippi between Minneapolis and St. Paul. Some snagging and dredging work has previously been done by the United States in the 237 miles from the mouth to Yellow Medicine River, but expenditures since 1895 have been for operation on the river, but for many years there has been but little commerce.

The district officer states that owing to the small low-water discharge, effective improvement of this river is practicable only by the construction of locks and dams or by storage of an adequate water supply in one or more reservoirs. The cost of the former method is considered prohibitive and therefore gives further consideration ~~and~~ to the use of reservoirs. It appears that three reservoir sites are possible, but careful investigation indicates that the Lac qui Parle is the only feasible one, having in mind the cost and resulting benefits.

The plan proposed involves the construction of a 45-foot dam at Lac Qui Parle, which will form a reservoir having a capacity of 30,000,000,000 cubic feet, cutting through sandstone

ledges at Little Rapids and some dredging and dike work elsewhere, which work it is thought by the district officer would insure a 6-foot depth at the mouth of the river, a 5-foot depth to Little Rapids, 35 miles above the mouth and a 4-foot depth to Morton, 206 miles above the mouth. The district officer estimates that the cost of the work proposed by this plan will be $1,375,000, and $3000 annually for maintenance.

In addition to improving the navigability of Minnesota River, it is expected that the reservoir will be of great assistance in attaining the project depth in the upper Mississippi River, since the amount of water stored in the Lac qui Parle reservoir would amount to about 64 per cent of the total which can now be counted on from the present reservoir system at the head of the Mississippi River; that it will permit the development of considerable water power; and and that it will reduce, though not entirely, floods.

The district officer is of the opinion that the construction of a reservoir at Lac Qui Parle is feasible and advisable and that it should be undertaken at once. He also believes that the work should be executed by the United States without cooperation on the part of power interests as the measure opposed- the former requring the discharge of 27,000,000,000 cubic feet during dry months and the latter requiring the 30,000,000,000 cubic feet to be discharged uniformly throughout the year.- and that any power rights should be leased for a proper compensation. The division engineer concurs in the views of the district officer.

These reports have been refered, as required by law, to the Board of Engineers for River and Harbors, and attention was invited to its report herewith, dated March 5, 1912. In connection with its consideration of this subject, the board held a public hearing at St. Paul, attended by a large number of interested parties and at which an offer of local cooperation was extended. There had been no concerted action to this end, and the subsequent efforts of the board were not productive of any proposition assuring actual saving to the government or an actual reduction of the initial cost. The board believed that the project would cost not less than $1,500,000. As stated fully in its report, the board did believe that a sufficient amount of commerce would be developed on the Minnesota River to justify the expenditure involved in the proposed improvement.

Since the receipt of the board's report, however, this office has received additional communications from the Secretary of the Minnesota River Improvement & Power Co. and Hon. K. Nelson, United States Senate, in regard to local cooperation.

After due consideration of the above-mentioned reports, the cheif rngineer of U.S.Army reported as follows: That the improvement by the United States of the Minnesota River, Minn., by the construction of a 45-foot dam at Lac Qui Parle, dredging,

dike work, and sandstone excavation where needed, with a view to creating an available channel depth of 6 feet at the mouth of the river, a 5-foot depth to Little Rapids, and a four foot depth to Morton, following in general the methods described in the report of the district officer at an estimated cost of $1,500,000 for first construction and $3,000 annually for maintenance is deemed advisable, provided that the State or other local interests bears one-half the estimated first cost thereof ($750,000) and the operation of the Lac Qui Parle reservoir be left entirely to the United States. These estimates are based on the supposition that the work will, as now seems desirable and advantageous, be prosecuted under a first appropriation of $500,000

Submitted to the Secretary of War by W. H. Bixby.
Chief of Engineers, U. S. Army.

The Board of Engineers for Rivers and Harbors, Washington, March 5, 1912. Respectfully returned to chief of Engineers, United States Army.

This is a report on survey authorized by the act of March 3, 1909, having in view the improvement of the Minnesota River and also a determination of whether for the maintenance of navigation storage reservoirs are necessary and what portion

of the cost of improvement should be borne by owners of water power and others. The survey and inspections connected herewith have developed the following facts:

For 24 miles above the mouth the river resembles a lake, having scarcely any fall. Above this point it is obstructed by shoals and rapids. Formerly boats were operated on the river, but for many years there has been but little commerce. Owing to the small low-water discharge, effective improvement is not practicable except by locks and dams or through the storage of an adequate water supply in one or more reservoirs. The cost of improvement by slack-water methods is clearly prohibitive, and therefore further consideration is given only to the use of storage water.

Three reservoir sites are possible, but careful investigation indicates that the Lac Qui Parle is the only feasible one, having in mind the cost and resulting benefits. The area of the land surface required by a reservoir at this site would be about 40,960 acres. The mean annual rain fall above the dam is about 214,000,000,000 cubic feet, the least being 160,000,000 000 cubic feet, 27 billion of which could be used for the benefit of low-water navigation, and it is thought by the district officer that this would insure a 6-foot depth at the mouth of the river, 5 feet to Little Rapids, 35 miles above the mouth, and 4 feet

to Morton, 206 miles above the mouth, at Little Rapids a cut through sandstone ledges would have to be made and some dredging and dike work would have to be done elsewhere.

The amount of stored water which would be made avialable for the benefit of low-water navigation would amount to about 64 per cent of the total which can now be counted from the present reservoir system at the headwaters of the Mississippi River. The result of the reservoir, therefore, would be not only to improve low-water navigation on the Minnesota River, but also on the Mississippi River at and below St. Paul, and would make the project depth for the Mississippi River more practicable of attainment. The minimum aviable head at the dam would be about 17 feet, which would permit the development of approximately 500 horsepower, and this would be much greater during the greater part of the year. The storage of water would also benefit existing waterpower at Granite Falls and at Minnesota Falls. While floods in the Minnesota Valley would be reduced, they would not be entirely prevented.

The population of the Minnesota Valley up to the town of Morton is about 55,000. At present there is no waterborne commerce, but the existance of extensive industries producing building stone and other products indicates a large tonnage that could advantageously be handled by water, if adequate facilities were available.

The district officer express the opinion, in which the division concurs, that the construction of a reservoir at Lac qui Parle is advisable, and that it should be undertaken at once. He believes the dam should be built by the United States without the cooperation on the part of power interests, as the navigation and power interests are in a measure opposed to each other, the former requiring the discharge of 27 billion cubic feet during the dry season, the latter requiring the whole 30 billion cubic feet uniformly discharged throughout the year. He stated that if the United States accepts assistance it would have to compromise with the power interests, perhaps to the determent of navigation.

In connection with its consideration of this subject, the board held board held a public hearing at St. Paul on October 19, 1911, which was attended by a large number of interested persons, many of whom addressed the board. Among the latter being Hon. F. C. Stevens, Member of Congress; Hon. A. J. Volstead, Member of Congress; Hon. H. Steenerson, Member of Congress; and Messers, C. A. Johnson, G. A. Ralph, Jos H Davidson, Dr. L. A. Fretchie, J. E. Townsend, and others. It was stated at that time that local interests would be glad to cooperate with the United States, but it was found upon inquiry that there had been no concerted action in the matter, and that those interested were not prepared to offer or suggest any specific plan. At the request of the board this phase of the subject was taken up and a plan of cooperation presented by the Minnesota Improvement and Power Company as follows:

First. That they would assist the Government in securing flowage rights for the Lac qui Parle Dam at the very lowest price possible in any way within their power by option or otherwise, as they may be advised.

Second. That they would at their own expense construct dams, reservoirs with power plants and equipments at Big Stone Lake and Red Wood Falls, making ample reservoirs both for storage and power purposes.

Third. That they would lease from the Government at such rental as it may be established generally in like undertakings based on the power made available for use at both the Lac qui Parle and Red Wood Falls Dam.

Fourth. Their people were anxious to cooperate by the acquisition and payment for whatever power may be available, and in addition by such voluntary help as their people may furnish through their organization. Their taxing power might be invoked to some extent, and if any favorable action by the board could be had, such could be used as a basis for securing cooperation among their people and later if necessary for such exercise of the public authority of the State as their constitution and laws will permit.

Fifth. It is extremely important to have considered at this time the urgency of the construction of the reservoirs as soon as possible, because there is the great increase of the price for land, which will be needed for reservoir sites. During the last ten years lands needed for reservoirs purposes have increased in price and value from an average of $10 per acre in 1900 to $30 in 1910. During the next ten years it is probably that this increase will continue and prices

for such lands will probably double, making the cost of such sites prohibitive on account of price. The association can secure through its effort the best possible options on these lands and save a large expense in acquiring them.

Later the Minnesota River Improvement and Power Company said: "We have made a canvas of all the farmers in the Minnesota Valley Whose land is subject to overflow and who will be directly benefited by the construction of the Lac qui Parle reservoir and the straightening of the Minnesota River. We found them, without exception, all willing to pay $5 per acre of the land actually overflooded, to the Minnesota River Improvement and Power Company, for the purpose of constructing the power house and install the electrical appatatus just as soon as the Government has constructed the reservoir. This money to the amount of $250,000 can be raised at once or just as soon as we know that the Government is willing to go on the improvement as per the recommendation of Major Shunk, district enginneer.

Our company is ready to at once acquire the flowage lands; that is, the option for the Government, just as soon as we know that the Government has accepted our proposition of cooperation."

The item of law calling for the examination requires investigation as to whether, for the maintenance of navigation, storage reservoirs are necessary at or near the headwaters of said river, and to determine what portion of the cost of said improvement should be borne by owners of power and others. The general law also requires that in all examinations of this character consideration shall be

given to the development and utilization of water power for industrial and commercial purposes, and such other subjects as may be properly connected with such subjects; provided further, that in the investigation and study of these questions, consideration shall be given only to their bearing upon the improvement of navigation and to the possibility and desirability of their being coordinated in a logical and proper manner with improvements for navigation to lessen the cost of such improvements and to compensate the Government for expenditures in the interests of power development.

The project now under consideration should therefore be considered first from the standpoint of navigation, second as to the possibility of development and utilization of water power, and third as to the benefits from the prevention of floods, the latter two only as far as they can be coordinated with the improvements for navigation to lessen the cost of such improvements and compensate the Government for the expenditures made in the interests of navigation.

The benefits to navigation would accure to both the Minnesota and Mississippi Rivers. There is at present no navigation on the Minnesota River, but there is apparently a reasonable prospect of a considerable development of such commerce, provided a good navigable channel were provided. The district officer states that the project recommended by him would insure a 6-foot depth at the mouth of the river, 5 feet to Little Rapids, 35 miles above the m outh, and 4 feet to Morton, 206 miles above the mouth. The board, however, is inclined to doubt whether a suitable channel of those dimensions could be secured for the expenditures proposed, and even so, a 4-foot depth is ordinarily not

sufficient for the development of a large amount of commerce of the character to be expected on this river.

The estinates for the impounding works and for the improvement of the river channel are believed to be sufficient for the accomplishment of the expected results and while the estimeated cost for flowage rights, compensation for existing improvements and raising railway tracks amounting to more than two-thirds of the total estimated cost of the project, are apparently reasonable, it is almost always the case that when lands and improvements have to be acquired by the Government, by condemnation or otherwise, the cost turns out to be larger than anticipated. While the Minnesota River Improvement and Power Company offers to assist the Government in securing flowage rights for the Lac qui Parle Dam at the very lowest price possible in any way within their power by opinions or otherwise, this gives no assurance as to any actual saving by the Government. The board believes, therefore, that the project would not cost less that a millon and a half dollars. The interest and maintenance charges would not be less than $50,000 per annum, and that the board does not believe that a sufficient amount of commerce would be developed on the Minnesota River to justify an expenditure of that amount

Not complete.

U. S. War Department on the Minnesota River proposed improvement.

By William T. Rossell, Colonel, Corps of engineers, Senior Member of the Board

Russell

Week of April 14, 1938

MISSISSIPPI RIVER PROJECT
(Water Power Ottertail River)

The Prudential Light and Power Company own a water Power on the Otter Tail River 8 miles east of Detroit of sufficient capacity to care for the needs of Detroit for many years to come. It has under consideration the plans of competent engineers for its development and transmission to Detroit. It is confident belief of the company and of other Detroit citizens that such power transmission will attract to Detroit manufacturing industries that will furnish employment for labor and result in great benifit to our city, and at the same time improve home conditions by doing away with the greater part of our present smoke nuisance and enable our Water and Light Board to make special quantity rates that will encourage the use of electric house conveniences, such as washing machines, cooking ranges, fans, irons and other up-to-date household conveniences.

In order to accomplish this result it is necesssary to provide in advance a market for portion of this power. Hence we desire to contract with your Honorable Boards to supply current for your Lighting, Pumping and Power Distributing Systems. To this end we make you the following proposition:

We will furnish electric current for pumping water and for all lighting purposes delivered at your switchboard at Detroit at four cents per kilowatt to the amount of four hundred thousand kilowatts per annum. Any amount you may annually require over and above four hundred thousand we will furnish at two cents per kilowatt. At the above named rate we are willing to at once contract with your Honorable Board for a reasonable number of years and to furnish suitable guarantees as to the faithful and complete performance of our part of the contract.

This proposition is made conditional upon our ability to secure the necessary franchises for the building, equipment and operation of a transmission line from the Otter Tail River to your switchboard at Detroit and on the further condition that your entire supply of electric current is to be obtained from us.

Respectfully submitted,

The Prudential Light & Power Co.,

By Henery Reinhardt (signed)
Its president

By A. C. Knudson (signed)
Its secretary

Report on a proposed Hydro-electric Development on the Otter Tail River in T 139 R 40 Becker County, Minnesota.

Dec. 15, 1919.

The Otter Tail River develops 55 feet of fall between the surface of Hubbell Dam when full, and a point near the east and west center line of section 26. The contour of the ground along the east side of the river makes possible the construction of a power canal, 3.6 miles long, between these two points, so that 90 feet of closed flume will make this head available, and the pond of the Hubbell dam is of such size that it will provide an excellent equalizing reservoir to care for the day to day variations in the output of the power plant. The canal and power house will be located in T 139 R 40, the head gates of the canal being on the east side of the river at the Hubbell Dam in the S. W. 1/4 of Section 12 and the power house being located near the east and west center line of Section 26. The power house will be a little less than 8 miles from the city of Detroit and like distance from the town of Frazee with intervening county that can be readily traversed by electric transmission lines.

The surveys and investigations show that the development of the project along the lines above outlined is possible and that, with arrangements made to supply the city of Detroit with electric current, as hereafter discussed, the project is practicable, unless the expense on account of land and riparian rights, and rights of way now being determined, prove too great.

The ownership of the rights of the lumber company which has for many years used the river for logging purposes, gives the project control of the water flow from a number of lakes, of which four, height of Land, Round, Many Point, and Elbow, are provided with water storage of 400,000,000 cu. ft., which is sufficient to provide, at the delivery end of a transmission line, 35 kilowatts of electric current continously for a year. This is equivilent to over 3/4 of the electric current used in the city of Detroit during the year 1918.

With the development of the other 3 lakes referred to for a 3 foot draw down there will be equalizing water storage sufficient to deliver electric current in an amount equal to 1 1/4 times the amount of current used in Detroit during the year 1918.

Drainage Area and Water Flow.

There are no Geoligical Survey Maps of the water shed tributory to the Otter Tail River above the intake point of the proposed power canal, but as a part of a report of the Chief Engineers, USA., in 1892, a map was made outlining the water shed of the river through out its length. From this it has been possible to obtain the ratio of the size of drainage area above the outlet of Otter Tail Lake, where a government gaging station was maintained for 5 years to that above the intake of the proposed

power canal, and to obtain the like ration for the government gaging station a few miles above Fergus Falls, which was maintained close to the same point, for 14 years, (station discontinued Sept. 1917.) These ratios are found to be 3.78 to 1 and 4.93 to 1 respectfully.

By applying these ratios to the flow measured at the gaging station, the proportionate flows at the intake of the proposed power canal are obtained, assuming the run off disributed uniformly over the drainage area. The result so obtained are likely to be low for the flows at the power project as the proportion of the rain fall which gets into a stream such as the Otter Tail River, is usually found to increase with progress up the stream; such increase being likely to amount to as much as 20 to 25%.

The application of the above ratios shows a flow at the proposed development averaging 70 cubic feet per second, during the 19 years for which records are aviable, and averaging 80 cubic feet per second for the years 1914 to 1917 inclusive; no record being aviable for 1918. There were three years during the 19 years for which records are aviable, when the flow of the river could not have been maintained at an average 60 cubic feet per second, when leaving out of account any increase in the proportion of run off from the upper drainage area of the river as compared with the lower.

Considering the 3 exceptionally low flow years referred to (1911, 12, 13) it will be inadvisable to develop the project for regular flow of greater than 60 cubic feet of water per second. But as there will be reserve equipment in the power plant which can be used for supplying power when there is excess water there will be some additional power for sale at such times. For all other years an average flow of 60 cubic feet per second could have been maintained and for the lowest year year during the 23 years for which records are aviable (1911) one and a half times the necessary flow to supply the power required by the city of Detroit. The precipitation for the year, which caused the exceptionally low precipitation accur in all parts of the country and come in long cycles of years. There was only one low percititation period for the 23 years for which records have been taken at Detroit and only corresponding period for the 29 years for which records have been taken at Park Rapids, which is twenty miles east of the water shed under consideration and for which the precipitation record show similar condition as for Detroit. The possibility that such a low period maybe experienced once in a long cycle of years must be faced but this situation is not a serious one when it is appreciated that a reserve capacity of a single 90 kilowatt generator and engine with 150 horsepower of boilers will supply the power necessary to carry over the lowest. But it is important to keep this situation always in mind when determining rates, in order that a sufficient margen of profit

will be maintained to meet the situation if it arises. Such a plant will cost not to exceed $20,000 at present prices and can be operated on the most economical bases, namely, with the engine generator and boilers always at economical load, in as much as the hydro-electric plant can always care for the variation in load.

The construction of such a plant need not be given consideration, except in the matter of rates to be changed, until half the output of the hydro-electric plant has been contracted for and then only when consideration of the precipitation records and the condition of the storage reservoir shows it necessary. This is likely to be a number of years in the future considering that the last flow period is only 8 years past.

Power delivered at Detroit

With 60 cubic feet of water per second under a head of 50 feet an average of 165 kilowatts of electric current can be delivered continuously in the city of Detroit, at the voltage now used on the circuts of the city. This over three times the amount of electric current that was distributed in the city in 1918 and 3 times the estimated amount that will be distributed in 1919. It thus seems that the continuous available power will be sufficient to provide the city electric plant with its power requirements with sufficient margin to supply twice as much more power to concerns not now using electric current, such as the

Braisdell Mell, or to other towns there will be also some excess power for sale to customers who can use electric current at times when excess water is available. This development contemplates the construction of a canal with its headworks having capacity for 200 cubic feet per second water flow, namely for the ultimate output of the development; of a pipe line from the canal to the power house 5 feet 6 inches in diameter with connections to three hydro-electric units; of 3 turbine generator units capable of a combined peak output of 480 kilowatts (640 horsepower) and having normal rating of 360 kilowatts peak capacity and 225 kilowatts normal rating; and of an 8 mile transmission line from the power house to Detroit with poles arranged to carry 13,200 volt circuits, with one no. 6 gauge copper circuit installed capable of delivering 300 kilowatts (400 horse power) to Detroit with 5.5 percent loss, and of delivering 600 kilowatts with 7 percent loss.

The development as above estimated has a capacity in the canal to care for the full continuous flow of the river under the ratio of maxium load to average load which isto be expected, namely 3.5 to 1. It has a capacity in the power plant for regular operation sufficient to supply power at Detroit of nearly one and one half times the 1919 power requirements of the city, while retaining a spare unit.

It has a capacity in step up and step down transformers equal to about one and one half times the 1919 power requirement of the city; and the transmission line is capable of carrying the power supplied when the plant is fully loaded without unreasonable loss.

Market for Power

A natural user for a portion of the output from the developments in the city of Detroit which in 1919 would have used about one third of the output than can be counted upon for regular service. The Blaisdell Mill would also be a natural user of the output, as properly installed electric power is found to be the best possible power for use in flowing mills.

In the matter of sales for excess power during high water years; such business usually has to be developed, but in most cities the possibility for the sale of such power arises when the consumers become acquainted with its possibilities.

Summary

The projected hydro-electric development can regularly supply an average of 165 kilowatts of electric current each year, at the delivery end of a transmission line. This amount to a little over 3 times the electric current that will be generated by the city of Detroit in 1919.

There is possibility of an extreme low rain fall period once in twenty to thirty years when an auxiliary steam plant of 90 kilowatt capacity will be required to maintain the delivered

current at an average of 165 kilowatts during such periods. How soon such plant will be required is not certain but it is likely to be a number of years in the future.

This will give assured output from the development sufficient to supply the electric current now generated by the city of Detroit; the power required by the Blaisdell Mill, and the electric supply for one of the neighboring towns, while leaving half as much power to be used for increase in consumption of customers.

For delivered power to an amount averaging 80 kilowatts of electric current (sufficient to supply the city of Detroit and Blaisdell Mill) no auxiliary steam plant will be required even at the period of ecaptionally low rain fall.

The project can be developed to provide the power necessary for the city of Detroit and the Blaisdell Mill for $84,000, exclusive of the costs for land and reparean rights and rights of way.

To increase the capacity of the development to its full output (namely sufficient to supply Detroit the Blaisdell Mill and one of the neighboring towns, with a half as much more power remaining for increase of customers demand) will will cost an additional $30,000.

To care for an exceptionally low rain fall period in case such occurs after the full development is necessary, a suitable steam auxiliary plant can be constructed for an outlay of not to exceed $20,000, and a total annual expense of 4,200.00

Signed - W. M. B. Jackson

MISSISSIPPI RIVER PROJECT
(TRIBUTARY)
(Water Power On St. Croix River)

The river and harbor act of March 3, 1925, contained an item providing for a preliminary examination and survey of the St. Croix from Stillwater, Minnesota, to its mouth. In accordance with this and instructions from the Chief of engineers, dated March 19, 1925, the following report of preliminary examination was submitted.

Geographical Discription

The source of the St. Croix River is in northwestern Wisconsin about 21 miles from Lake Superior and approximately 1,013 feet above sea level. The river is 166 miles long and drains an area of about 7,290 square miles. From its source it flows in a southwesterly and then southerly direction, forming for a greater part of its length the boundary between the States of Minnesota and Wisconsin. It joins the Mississippi River at Prescott, Wisconsin, about 27 miles below St. Paul.

Locality

The section of the St. Croix River under consideration in the report extended from Stillwater, Minnesota, to the mouth, a distance of 23.6 miles.. Known as Lake St. Croix, it is a natural lake with no appreciable slope nor current. Its fromation is generally attributed to the fact that in the past-glacial period of the Mississippi River, carrying considerably greater quantities of detritus than the St. Croix, built

up its bed at a faster rate and formed a dam of sand and gravel across the mouth of the St. Croix valley.

The lake varies in width from 1,500 to 6,500 feet and in depth from 20 to 35 feet. It is bordered by bluffs about 200 feet high, whose sides are covered with grass and trees.

Work Previously Done

Work of ~~improvement of~~ improving the St. Croix River was commenced above Stillwater in August, 1878, and below Stillwater in the latter part of the season of 1882. The work at and below Stillwater comprised the construction of a training dam and wing dam at Hudson Bar, a wing dam at Catfish Bar near Afton; the dredging at Catfish Bar, Hudson Bar, and the harbor at Stillwater.

The total expenditures to June 30, 1925, for improvement of the St. Croix River from Taylors Falls to Stillwater were $161,265, of which $29,855.50 was for maintenance. The portions of these amounts which has been applied to the improvement of the section of the river under consideration in this report cound not be determined.

The project for improvement of the St. Croix River was considered as having been completed in 1900. Expenditures for maintenance during the past few years have been small, and the channel ~~had~~ has deteriorated.

At Stillwater the ordinary fluctuations between mean low and mean high water are about 10 feet, and between extreme low and extreme high about 17.8 feet. Sinee there is very little fall in the river from Stillwater to the mouth, the stage in this section is largely con-

crolled by the stage of the Mississippi River. Low stages during the navigation season ordinarily occur in the late summer and fall and high stages in the spring. The river is closed by ice from the middle of November to the middle of April. The flow varies from a minimum of about 1,140 second feet to a maximum of about 37,200 second-feet.

At the St. Croix Falls Dam, three-quarters of a mile above the bridge of Taylors Falls, the discharge at low water is 1,200 second-feet; at extreme high water 35,800 second-feet. During the lower stages the flow is manipulated by the power company located at St. Croix Falls. The low stages occur during July, August, September and October; high stages in April, May and June. From Taylors Falls to Lake St. Croix, a distance of 27 miles, the width is 130 to 800 feet and the fall is 0.7 per mile.

The then existing project provided for dredging, construction of wing dams, and bank protection between the mouth and Taylors Falls (a distance of 52.3 miles) to obtain a channel 200 feet wide and 6 feet deep at low water between the mouth and Stillwater, and a channel 3 feet deep at mean low water between Stillwater and Taylors Falls; also the improvement of the harbor and waterfront at Stillwater. The ordinary fluctuations between mean low and mean high water are about 7.5 feet at Osceola and about 17.8 feet at Stillwater.

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Immediate re-establishment of a three foot channel in the St. Croix river from Stillwater to Taylors Falls was demanded of the government by residents of Minneapolis and St. Paul and the region adjoining the river at a public hearing late Thursday in Stillwater. 1922
(What is the specific date?)

The hearing was called and conducted by Lieut. Col. Wildurr Willing, U. S. district engineer, to determine the necessity of regulating operations of the Northern States Power company's dams at St. Croix Falls, Wisconsin, and above, and to discuss the feasibility of re-establishing navigation on that section of the St. Croix.

Complaints of the St. Croix Improvements association against the present condition of the channel and charges by residents along the river that the power company at times completely shut it dam to accumulate water, led to calling of the hearing.

In 1918 the war department ordered the power company to permit a flow of at least 800 cubic feet per second through the dam when the flow of the river was 1,200 cubic feet a second, and to maintain a two-thirds natural flow when below 1,200 feet.

Complaints that the river at times was nearly dry under this method of maintaining the flow, resulted in an order by the war department last spring that a flow of 1,600 cubic feet a second should be maintained, or the natural flow allowed when it fell below 1,600 feet.

(Tourtelotte says "they" refer to St. Croix Improvement Assn.)

Conditions this summer have been better, despite the drouth. They joined in ~~demand~~ demanding, however, that the order be kept in force through the year, instead of being suspended at the close of navigation October 31.

L. D. Smith of Minneapolis, representing the power company, presented a letter signed by Harry Grenacher, assistant general manager in charge of operations, assuring cooperation of the company in maintaining an adequate flow for a channel and suggesting a 1,200-foot flow when

the river was average and the natural flow was below that. ~~that.~~ The proposal met with strong objection, however.

A channel adequate to maintain aquatic life and to float pleasure boats was demanded by Judson L. Wicks and Minneapolis, president of the Minnesota division of the Izaak Walton league.

Commercial possibilities of the channel were pointed out by Edward Thelen of Stillwater, chairman of the board of the improvements association.

Minneapolis Star, October 10, 1930.

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A fight between Minnesota and Wisconsin over the electric power developed by the St. Croix river, was initiated in a letter sent to Senator Irvin L. Lenroot and Representative Joseph D. Beck from the Wisconsin railroad commission , appealing to Beck to protest against the petition of the St. Paul (what?), filed with the Federal Power commission and the acquisation of water power sites on the St. Croix river.

(?)

The plan of St, Paul is to develop a large industrial center near St. Paul, the commission says and asks Governor Blaine to protest to Chairman Weeks of the power commission against the contemplated action of Minnesota.

If the power commission grants the petition, Wisconsin will be unable to acquire power development on the rivers in the state to benefit Wisconsin industries.

The commission suggests that if Minnesota industries should have the benefit of Wisconsin water power, they should operate in the state and incorporated as Wisconsin corporations.

St. Paul Pioneer Press, August 3, 1922.

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