REPORT ON THE WATER-POWERS

OF THE

DRAINAGE BASINS OF LAKES HURON AND ERIE,

IN THE

UNITED STATES,

WITH REPORT ON THE

WATER-POWER OF THE NIAGARA RIVER,

BY

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NEW YORK, N. Y., *April* 1, 1883.

Professor W. P. TROWBRIDGE,

Columbia College, New York, N. Y.

SIR: I beg to submit herewith my report on the water-powers of the drainage-basins of lakes Huron and Erie in the United States, and on the water-power of the Niagara river.

Most of the investigations on which this report is based were made in the winter and spring of 1880-'81, and it should be remembered that since that time considerable changes have taken place in the power utilized, especially so at Niagara falls, where important improvements were being made during my visit.

Very respectfully,

JAMES L. GREENLEAF,

Special Agent.

EASTERN DRAINAGE AREA OF THE LOWER PENINSULA OF MICHIGAN.

GENERAL DESCRIPTION OF THE REGION.

The area is bounded on the east by lake Huron, Saint Clair river, lake Saint Clair, Detroit river, and lake Erie. The distance from these navigable waters to the line of water-shed is not more than 70 or 80 miles. The land is quite level, rising toward the northern part. In the lower part the soil is a sandy or gravelly clay, well adapted to raising wheat, which is the staple. In the northern part there is much pine lumber cut. The rivers are short and not of large size; those in the upper part of the region are mainly devoted to rafting. There are no very important water-powers to be found.

No rivers north of the Saint Clair were visited. There are powers in use on the northern rivers, especially the Thunder Bay river, but they are used for saw-mills and local grist-mills, and have not the importance they will probably possess when the country is more settled.

The rivers have only in a few instances reached the rock; they have worn their beds in the drift, which here covers the rock in a deep layer. Hence the dams have mostly an earth foundation, which is, however, a compact gravelly clay, and the banks are usually high enough to restrain the ponds within small limits.

None of the rivers are navigable except for short distances, and are used, as far as shipping is concerned, only for harbors. The fact that many of the rivers on which it would now be almost impracticable to float even a flat-boat have been once declared navigable by the legislature or by Congress, indicates the change in flow that has taken place, owing to the clearing and draining of the land.

HURON RIVER.

General description.—The Huron river rises in the town of Clarkston, Oakland county, Michigan, and runs southwest into Livingston county, draining many lakes in Oakland county. The chief of these are White, Union, Upper Straits, Lower Straits, Pine, and Spring lakes, averaging ½ to 1 square mile in area. In the southeast part of Livingston county it takes the waters of four lakes, viz, First Base lake, Second Base lake, Strawberry lake, and Portage lake, varying from 1 to 2 square miles in area. Portage lake is the largest and also the lowest down the valley of all the lakes drained by the Huron. It is 3 or 4 miles long, and averages about ½ mile in width. It is fed by Portage river, which itself drains ten lakes of small size. From there the Huron flows northeast, then southeast again, and enters lake Erie just below the mouth of the Detroit river. The total drainage area is 950 square miles.

The country is flat or rolling, with a glacial drift of clay, sand, and gravel, well adapted to the raising of wheat, which is the staple, and gives work to many flouring-mills. The river was declared navigable by Congress. Once a flat-boat for freighting ran from Ypsilanti 30 miles to the mouth, but its use was discontinued on the advent of railroads. There was too little water for navigation, and the dams interfered. Boats run up to Rockwood, 4 or 5 miles upon the line of the Lake Shore and Michigan Southern railroad.

No lumbering is done, and the stream is devoted to manufacturing, for which it stands peculiar among the rivers of the region. It has a fall averaging 5 feet per mile, and this near its mouth. It is in line of several railroads, and, owing to its lakes, the storage capacity is large and its flow more regular than that of various other rivers of the country. There has been talk for some years of throwing a dam across the outlet of Portage lake and increasing the storage, but nothing has been done as yet. The banks of the river are usually from 9 to 12 feet high, and hence ponds do not spread. The bed and banks are usually hard clay, or a sort of conglomerate of clay, gravel, and stone. There is no rock bed except at Flat Rock, the first fall above the mouth.

The course is extremely winding. The Michigan Central railroad runs along the river 17 miles from Ypsilanti to Dexter, and in that distance crosses it sixteen times. The bulk of the manufacturing is done between Dexter and Ypsilanti, on the line of the Michigan Central railroad.

The Michigan Southern railroad crosses at Rockwood, the Chicago and Canada Southern railroad crosses at Flat Rock, and the Flint and Père Marquette railroad crosses at New Boston. There is a road projected between Detroit and Adrian, in Lenawee county, which will cross at Belleville and open up a short stretch of river.

Character of the river.—At Ypsilanti, the center of use of power, the average breadth is 100 feet, average depth 1½ foot, and the maximum depth about 5 feet. The ordinary low-water flow, calculated from the estimated horse-power given, is 220 cubic feet per second, or 0.23 cubic foot per second per square mile of drainage area. The available power under 10 feet head at ordinary low water is from 225 to 250 horse-power. There is no difficulty from floating ice. A mill using the full average power of the stream can run full capacity ten months of the year, and during September and August at half capacity. The river has no large tributaries below the lakes, and hence the power for a given fall is nearly the same in the upper as in the lower part.

DESCRIPTION OF THE DEVELOPED POWER.

Most of the mills are between Dexter and Ypsilanti, a distance of 17 miles. Above Dexter and below Portage lake are the Hudson and the Dover mills. Below Ypsilanti are mills at Rawsonville, Belleville, etc.

Three methods have been employed for building dams: 1. The pile dam, a common form. A typical specimen is one belonging to the Ypsilanti Paper Company. Piles were driven 6 feet between centers, both across and lengthwise of the stream, till they covered a strip 50 feet wide running across the channel. The ends were then cut, so that taken together their surface formed two planes meeting at the center line of the dam, like a roof. The space between the piles was filled in with stone and the top planked over. A plank apron was built on the lower side. 2. The crib-work dam—ordinary timber cribs, filled with stone and planked over. 3. The frame dam, used at the Dover mills. A triangular frame was built and planked over and stone thrown under; a plank apron built on the lower side, and gravel thrown in on the upper side. So far as ascertained, there have been no instances of the breaking away of dams.

Flat Rock.—At Flat Rock, 7 or 8 miles above the mouth of the river, is the first power. There is about 100 horse-power available.

New Boston and Belleville.—At New Boston and at Belleville are powers which are being developed. There are two flouring-mills at Belleville. Banks high and well adapted to ponding.

Rawsonville.—At Rawsonville is a flouring-mill with 7 feet head. There is 150 to 175 horse-power available.

Ypsilanti.—Ypsilanti is the chief manufacturing center on the river. There are three paper-mills, two flouring-mills, a woolen-mill, and a small custom saw-mill. The banks are from 9 to 12 feet high, and ponds do not spread. There are three dams with about one-half to three-fourths of a mile between them, and there is no fall wasted. The bed is hard clay. The Michigan Central railroad runs up the valley from this point, and freight facilities are good.

The lower pond has 7 feet available fall and 175 available horse-power. Pile dam, 190 feet long. Average breadth of pond, about 150 feet; length, half a mile. Power utilized by Ypsilanti Paper Company's mill.

The middle pond has 5 feet available head and 125 available horse-power. The only mill at the power is the Huron flouring-mill, using, on the average, 75 horse-power. Pile dam, 5 to 6 feet high and 100 feet long. Pond, from 150 to 200 feet broad and half a mile long.

The upper pond is owned by the City flouring-mill and the woolen-mill, and runs them, as also a small saw-mill fed from the race of the flouring-mill. The fall at the dam is 8 feet and the available power is 225 horse-power. Dam, from 120 to 130 feet long; area of pond, 35 acres, and depth 5 or 6 feet; it does not spread much. The woolen-mill uses 42 horse-power. The flouring-mill, situated on a race, has 1 foot additional fall, making it 9 feet; it uses 100 horse-power. The saw-mill uses, when running, about 10 horse-power.

Peninsula Paper Company's mills.—The mills of the Peninsula Paper Company are situated at a pond a short distance above Ypsilanti, and have 300 available horse-power.

Lowell.—The largest power on the river is at Lowell, and is used by the Ypsilanti Paper Company. The available head is 16 feet, and 400 horse-power is available. The pile dam has been described; its length is 166 feet. The area of the pond is 30 or 35 acres.

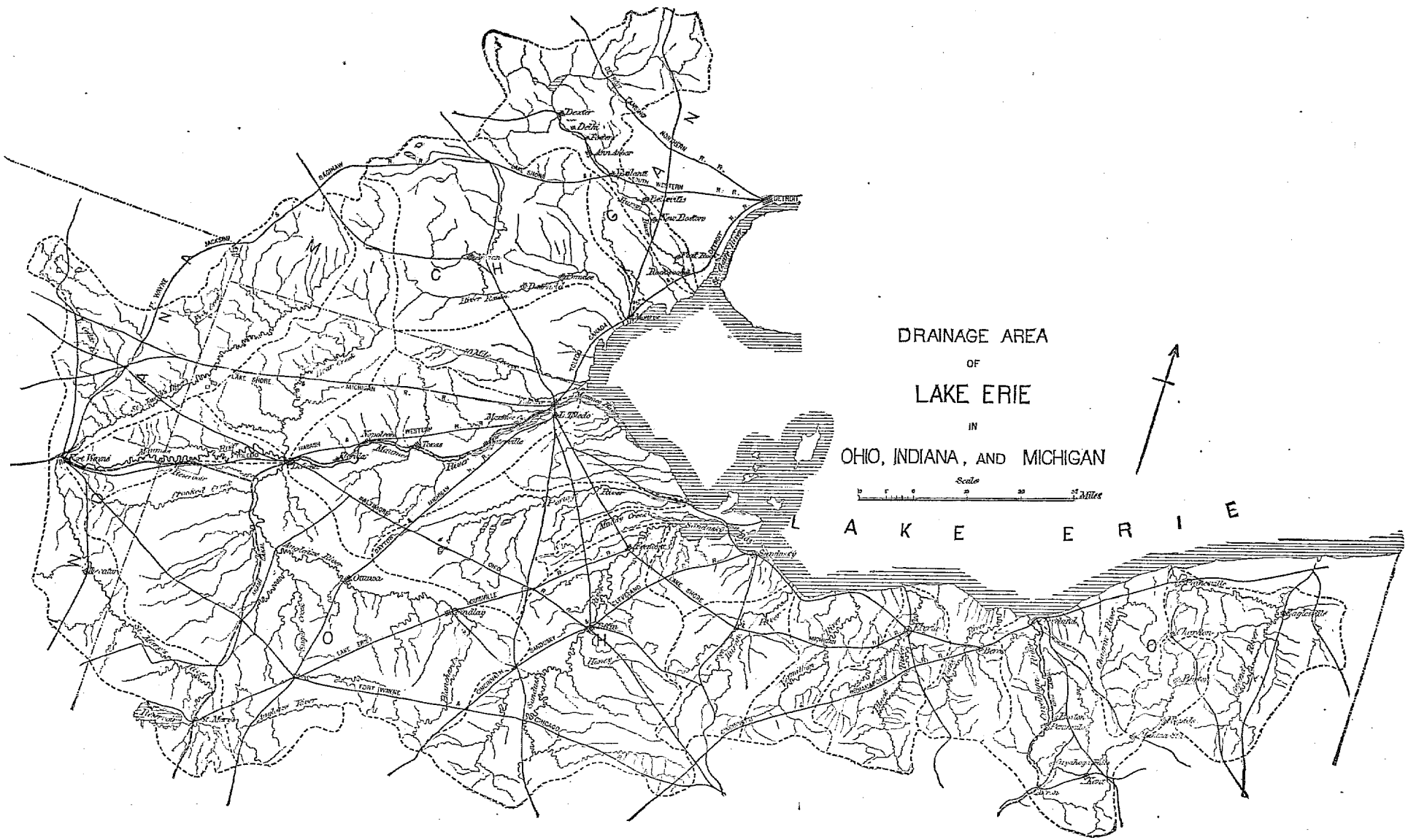
Ann Arbor.—At Ann Arbor, 7 or 8 miles above Ypsilanti, there is a level with a head of 10 feet and 250 horse-power available. The dam is a pile dam 200 feet long; it is utilized by the Ypsilanti Paper Company's mill. Above it is another level with the same head and power. There are a woolen-mill, flouring-mill, and saw-mill fed from this pond, using altogether 100 horse-power. The dam is 140 feet long.

Foster's Station.—At Foster's Station, 3 miles from Ann Arbor, there is a fall of 9 feet, all of which is utilized by a paper-mill taking 100 horse-power, and a woolen-mill with 58 horse-power. The power is considered to be 300 horse-power for six months of the year.

Delhi.—At Delhi there are 2 flouring-mills, a woolen-mill, and a saw-mill, all using from the same level. Seven feet head and 140 horse-power are available. Usually all can run at once. The dam is a crib-work 150 feet long.

The Scio flouring-mills are above Delhi, and have 8 feet fall, with 140 available horse-power. The dam is a crib-work 100 feet long.

Dexter.—Dexter has a flouring-mill, a woolen-mill, and a saw-mill, all run from the same level. The available head is 5 feet. The dam is a crib-work 75 feet long.


DRAINAGE AREA
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O H I O
I N D I A N A

Above Dexter.—Above Dexter are the Hudson mills, with 5 feet head and 75 horse-power—a crib-work dam 100 feet long—and the Dover Mills, with 7 feet head and 100 horse-power—a frame dam 100 feet long. The ponds above Ann Arbor average from 120 to 180 feet wide, and ½ mile to 2 miles long. There are no important powers above.

UNIMPROVED POWERS.

There are few undeveloped powers. Three miles below Ypsilanti is one of 300 horse-power, which has not been used, because the pond would spread over valuable farming land, and also because the location is not near the railroad. One mile below Ann Arbor is a power with 4 or 5 feet fall unimproved, giving from 100 to 125 horse-power. It is on the line of the railroad. The small power, compared with the cost of improvement and lack of demand for it, is the apparent reason why it is not improved. One and one-half mile above Ann Arbor is a fall of 10 feet unimproved. Nearly 300 horse-power is wasted. It was used formerly by a saw-mill, now burnt down. It is on the line of railroad, and awaits improvement.

RAISIN RIVER.

The North branch rises in Jackson county, and the South branch in the northwestern corner of Ohio. They unite east of the center of Lenawee county and flow into lake Erie. The drainage area is 1,162 square miles. Near the mouth it is 200 or 300 feet wide, and would be thought a large stream, but it is, in ordinary water, only from 6 to 12 inches deep, with a sluggish current. At Adrian it is a small stream, 25 or 30 feet wide, with a moderate current, about 1 foot deep. There are several small mills on the river, but no power of importance.

SOUTHERN DRAINAGE AREA OF LAKE ERIE.

GENERAL DESCRIPTION OF THE REGION.

The average altitude of the water-shed above lake Erie is 500 feet. It crosses Ohio from northeast to southwest. Entering in Ashtabula and Trumbull counties it runs through the north line of Wayne and Richland, through Hardin, Auglaize, and northern Darke county into Indiana.

Along the shore of lake Erie the water-shed hardly runs back more than 50 miles from the lake, but in western Ohio it extends nearly half way down the state line. This gives a longer surface of drainage in that section, and hence the Maumee is the largest stream of northern Ohio. The elevation, however, at its head, Fort Wayne, is only 170 feet above the lake level. The headwaters of the Cuyahoga, in eastern Ohio, are 500 feet above the lake. The soil is mostly the Erie clay (in the southern part of the shed more arenaceous), which was deposited by a body of water in a blanket over all irregularities of surface. This has been worn by the stream into undulating ground, but the surface is everywhere of only slight variation where not level. Owing to the narrowness of the region of drainage the streams are small, the chief being the Maumee, the Sandusky, and the Cuyahoga, and the power is not very considerable. The land is well adapted to the raising of corn and wheat, which are the staples, except in the northeastern part of Ohio, where there is a section devoted to cheese- and butter-making. The timber is largely oak, some beech and maple, and a few firs. One peculiarity concerning the water-power is, that a large part of it is situated on the canals, the Miami and Erie entering the lake at Toledo, and the Ohio canal entering at Cleveland. These canals are controlled by the state of Ohio, and the power is rented to the manufacturers. The universal opinion of the persons consulted was, that the rivers had become unsteady in flow since the country was cleared and drained; some rivers that once were steady and gave good power are now so flashy that the mills have been abandoned or are being run by steam.

MAUMEE RIVER.

The Maumee river is formed at Fort Wayne, Indiana, by the junction of the Saint Joseph and the Saint Mary's rivers, and flows northeast into lake Erie, at Toledo. The chief tributaries below the junction are the Auglaize and the Tiffin.

The drainage area in square miles above different points is as follows: At the junction, 2,055; above Tiffin river, 2,412; below Tiffin river, 3,135; below Auglaize river, 5,676; at the mouth, 6,723.

The country is flat, and the river has not worn its valley very deep. The soil is the Erie clay, which when not too heavy is well adapted to the raising of wheat and corn, the staple crops. Farming is the occupation of the people. There are many limestone quarries locally used for building, and some brick-yards. In places are many artesian wells. Oak timber covers a considerable portion of the land. Oak is rafted to some extent from the headwaters of the Auglaize.

The Miami and Erie canal runs up the valley to Defiance, and then turns south. It is carried in the river by slack-water navigation from Providence to Defiance, a distance of about 30 miles. The river is practically taken

up by the canal, and hence no power is used to any extent from it, but there is a large amount taken from the canal itself. South Toledo is the head of natural navigation 18 miles from the mouth. Here begin the rapids, which continue about 1 mile. There are also rapids at Waterville and Otsego. All these are of no value, because, except when the water is high, there is no regularity in the flow, owing to the canal taking it.

The river is 600 feet wide at South Toledo and from 1 to 6 or 7 feet deep. It is subject to high freshets—the Saint Joseph rose 23 feet above low water at Fort Wayne on March 28, 1868—and after hard winters there is too much floating ice.

While the river is spoiled for milling purposes by the canal, yet the manufacturers gain in having their power from the canal much more securely than they could get it direct from the river. There are only two powers used from the river direct. One at Perrysburg, opposite South Toledo, takes its water by a race 5 miles long from a small dam just below the canal dam at Providence, and gets what water flows over the canal dam. It is a very unsteady power, and steam is also used. The other is opposite Providence, and is fed by a race 1½ mile long from the canal pond. From Providence to Defiance the fall is all taken up by the slack-water for navigation. From Defiance to Fort Wayne there is some fall, but not utilized.

The bed of the river is rock, up to Defiance at least, with clay and gravel banks. At Fort Wayne the bed partakes more of a gravelly and clayey nature, for the river has not eroded to the rock at its upper part.

Twenty-four miles above Defiance are the Bull rapids, where there is a fall of 14 feet. There is a rock bed, and banks high enough to confine the pond. This is not utilized, but backwater during floods is a serious objection to using the power on the upper part of the river. The flow of the Maumee at Fort Wayne during ordinary low water was estimated by an engineer at 116.6 cubic feet per second, which is 0.57 cubic foot per second per square mile.

TRIBUTARIES OF THE MAUMEE RIVER.

SAINT JOSEPH RIVER.

The Saint Joseph river rises in Michigan and flows southwest into Indiana, uniting at Fort Wayne with the Saint Mary's to form the Maumee. The drainage area is 1,292 square miles.

These rivers change their course through an angle of about 150 degrees at Fort Wayne. This may be due to the fact that these rivers once emptied into the outlet of the lake which flowed down the Wabash valley, and have their directions changed by the subsidence of the lake level, and the wearing of their beds below the level of the headwaters of the Little river, which occupies the old channel. The river gives in ordinary low water 67 cubic feet per second; fifty years ago it was estimated to give 83 cubic feet per second.

There is considerable fall in the river—3 feet per mile near the mouth—and the census returns show a total of twenty-four grist- and saw-mills, using 925 horse-power. The highest head is 26 feet. By throwing dams across the Saint Mary's and Saint Joseph, and bringing the water to Fort Wayne in canals, a flow of 117 cubic feet per second can be obtained with 17½ feet available fall, giving 232 theoretical horse-power. The project is feasible.

SAINT MARY'S RIVER.

The Saint Mary's river has 763 square miles of drainage area. The ordinary low flow is estimated to be 33 cubic feet per second. There is power at the mouth which can be utilized at Fort Wayne, as just mentioned.

The ordinary low-water flow has been much increased by taking the overflow of the 15,000-acre canal reservoir in Mercer and Auglaize counties. There are only three mills on the Saint Mary's, and these use a total of 210 horse-power. The bed and banks are generally clay and gravel.

AUGLAIZE RIVER.

The Auglaize river enters from the south at Defiance. It divides into two large branches at Franconia—one from the east and the other from the south. The drainage area is 2,541 square miles. It is 300 feet wide and 1½ foot deep during low water near the mouth. The average grade for 5 miles above Defiance is 6 feet per mile. By building a dam 2 miles above Defiance and running the water along the bank in a canal there could be obtained in Defiance a fall of 30 feet. Mills could be stationed along the side of the canal on the river-bank. For about $10,000, it is said, a fine power could be obtained.

The grade to Delphos, 50 miles, averages nearly 6 feet per mile. Ten miles above Defiance is a fall which might be utilized. The bed and banks are generally clay and gravel. The river is subject to high freshets. There are only three mills on the river, using 82 horse-power, but a dam could be thrown across nearly every 3 miles without interfering. The chief difficulty is backwater during freshets.

TIFFIN RIVER.

The Tiffin river rises in Michigan, and after draining 723 square miles enters the Maumee 2 or 3 miles above the Auglaize river. There is a total of 16 grist- and saw-mills on the river, using 590 horse-power, but none are very important. A survey has shown it practicable to cut a canal from Brunersburg down into Sulphur Hollow, at Defiance, and obtain a large head there.

MIAMI AND ERIE CANAL.

Practically all the utilized water-power of the Maumee valley up to Defiance is on the canal. It was formerly called the Wabash and Erie. It is practically discontinued west from Defiance, but runs south from there to Cincinnati. At Providence a dam gives slack-water in the Maumee to Independence, and another dam there continues it to Defiance. The Providence dam was built in 1872.

The old dam leaked badly and was dangerous. The bed is rock. Ten feet below the old dam a crib of timber 10 feet wide filled with stone was placed across the stream. The space between was filled with gravel, and the whole was planked over. The dam is built on both sides of an island, and averages from 6 to 8 feet high.

UTILIZED POWERS OF THE CANAL.

The total power in use on the canal within the water-shed is about 2,000 horse-power. The millers complain that the feeding of the canal is not regular, and as they get only the surplus from what is needed for locking, they are sometimes short for water. The average surplus is about 45 cubic feet per second at Toledo.

Toledo.—At Toledo are the Pilloid flouring-mills, which use 12 feet fall and pay $800 per year, and the Amada mills, which have 24 feet fall and average 120 horse-power.

South Toledo.—At South Toledo are three paper-mills, two flour- and grist-mills, a woolen-mill, a cotton factory, and a foundery. Four of the powers are taken direct from the canal, and four from the tail-races or head-races of the others. The heads used are 31, 11, 16½, 16½, 16½, 24, 16½, and 16⅔ feet, respectively. The total power used is about 520 horse-power.

Waterville.—At Waterville are a grist- and a saw-mill, using 60 and 25 horse-power, under 17 and 16 feet head of water, respectively.

Providence.—At Providence is a flour- and grist-mill using 20 horse-power. The head is 9 feet, and 100 horse-power is available.

Texas.—There is a mill at Texas using 15 horse-power under 17 feet head. The available head is 21 feet.

Damascus.—At Damascus is an available power of 21 feet, of which a saw-mill uses 18 feet and 18 horse-power.

Napoleon.—At Napoleon are two flouring-mills, a woolen-mill, a planing-mill, and a saw-mill. The heads used are 22, 18, 20, 16, and 20 feet, respectively, and the total power is 214 horse-power.

Florida.—There is one grist-mill at Florida using about 30 horse-power.

Defiance.—At Defiance are two flour- and grist-mills, a woolen-mill, a planing-mill, and machine-works. The heads used are 11½, 14, 17, 16, and 7 feet, respectively, and the total power used is about 214 horse-power.

Junction.—At Junction is a grist-mill, with 21 feet head and 12 horse-power.

From Junction west to Fort Wayne there is no power used on the canal, and the only use made of it is for local traffic. It is much run down. In Indiana the canal was sold to a private company and is going to ruin.

Fort Wayne.—At Fort Wayne there are two flour- and grist-mills and a woolen-mill. The heads are 16, 16, and 17 feet, respectively, and the total power now used is 170 horse-power. One of the flouring-mills does not use the power, because of litigation. On the branch of the canal running south from Defiance there is, according to the census returns, about 670 horse-power used north of the water-shed line, by twenty establishments, chiefly flour- and grist-mills.

PORTAGE RIVER.

The Portage river drains 695 square miles, and flows northeast into lake Erie just north of Sandusky bay. The region drained by it is the eastern end of what was known in the early years of the state as the Black swamp, a strip extending through the northwestern end of Ohio and into Indiana. Formerly there were several mills on the river, but since the draining of the land the river wastes to almost nothing during a dry season, and all these mills are discontinued. The upper branches of the river have been deepened and turned into a series of ditches by the county authorities, also the waters of Hancock and Putnam counties have been diked off and turned into the Maumee to make the land suitable for farming.

SANDUSKY RIVER.

There is slack-water to Fremont, the head of Sandusky bay. Above Fremont the fall is 75 feet up to Tiffin, 4 feet per mile. It is on this stretch of 18 miles that nearly all the mills are situated, the fall not being so much above Tiffin. There are no lakes, but several creeks tend to keep up the flow. Several enter just above Fort Seneca, and make the river especially steady at that point.

The stream presents the average features as regards freshets, being perhaps rather flashy. It has gone down to 10 horse-power under 8 feet head, and up to 1,000 horse-power under the same head. The average power of ordinary low water under 9 feet head is 45 horse-power. The area drained is 1,457 square miles.

At Tiffin, below the railroad bridge, the bed is very rocky and there is considerable fall. The channel here is about 200 feet wide, and when visited the stream was low and flowed in several small channels between the rocks. The banks are high at Tiffin and restrain the ponds to the river-bed. There is no unimproved fall between Fremont and Tiffin, one level backing up nearly to the foot of the other. The bed of the river is mostly rock.

Utilized power.—From the lowest power at Fremont the utilized powers are as follows, in ascending order: At Fremont is a flour- and grist-mill, with 6½ feet head and about 40 horse-power. Above is a power of 15 feet head and 70 horse-power, running a tannery, a woolen factory, and a flour- and grist-mill. Next a flour- and grist-mill with 17 feet head and 40 horse-power used. A saw-mill with 8 feet head and 40 horse-power. Near Fort Seneca a power with 9 feet fall and 60 horse-power, running a flour- and grist-mill and a saw-mill. Above this is a saw-mill with 14 feet and about 80 horse-power. Then a power of 24 feet head, 150 available horse-power, of which half is used by a flour- and grist-mill and a saw-mill. Then a flour- and grist-mill, using about 50 horse-power under 14 feet head. Next a flour- and grist-mill, using 50 horse-power under 7 feet head.

At Tiffin there is a power with 7 feet head available, and all is used; 40 horse-power is available on the average, and runs a grist-mill and a saw-mill which can run full capacity eight months of the year.

The dam is built of logs and frame, and is situated just at the rocky ledge already mentioned. The banks are high, and the pond is 200 feet wide by 1½ mile long.

The Tiffin water-works are situated in the town, and pump water from the river.

The fall is 10 feet, and about 60 horse-power is available. There is liability of an insufficiency of water to do the pumping, and steam is used to aid. A grist-mill on the same pond runs when there is surplus water.

The next power has 7 feet head. The pond backs up 7 miles, and in one place spreads to some extent. When the gates are shut for three or four days the supply below is small. There are a flour- and grist-mill and a saw-mill, using about 35 horse-power during low water. There is only one mill above this and below Upper Sandusky. It is a grist-mill, with 5 feet fall and 20 or 25 horse-power. There are no mills of any importance at or above Upper Sandusky.

From the Sandusky river east to the Cuyahoga there are several rivers, as the Huron, Vermilion, Black, and Rocky rivers, which are small, draining 300 or 400 square miles, and which run a few small mills doing custom work, and are not specially important.

CUYAHOGA RIVER.

General description.—This is the largest river of northern Ohio east of the Maumee. The valley is the result of erosion, as with all the streams of the region, but here the action has been enough to leave hills 200 feet or more in height, which at places give an element of wildness to the quiet beauty of Ohio scenery. The river rises in Chardon, Geauga county, 20 miles from the mouth at Cleveland, and, yet it flows 75 miles, and, if all the windings were measured, at least 100 miles, well deserving the Indian name, Cuyahoga—"Crooked river".

The course is south-southwest to within 2 miles of Akron, and then it sweeps sharp around and flows northwest to lake Erie; it is extremely winding. In one place a straight line 5 miles long would touch two points on the river 12 miles apart by the channel. Above Hiram rapids a ledge of rock stretches across the stream and backs the water into Chardon township, making it a great underground reservoir with many lakes and swamps. These and the springs maintain a somewhat steady flow. In Portage county are at least nine lakes, and many are in Geauga county. The river is larger in its upper part than near its mouth, because fed into the Ohio canal. At Peninsula it averages 130 feet wide and at Cuyahoga Falls 70 feet wide, but near the mouth it is in many places not more than 20 feet wide and 1 foot deep. The flow at Cuyahoga Falls is about 67 cubic feet per second during ordinary low water. The rise due to freshets is 8 feet at Peninsula and 5 feet at Cuyahoga Falls.

There is no special liability to ice-gorges except at the mouth, where there is slight danger of flooding the Cleveland flats and doing great damage, as in 1860, when the flats were covered with 4 feet depth of water. The river was declared navigable by the government, but is used now only for water-power and for feeding the canal. The valley is cut through the Carboniferous conglomerate, Waverly shales, and Erie shales.

At the bend at Akron the basin is very large. The falls were once in Cuyahoga county, and have since worn their way back to their present position above Akron. The plane at Cuyahoga Falls is about on the level of the hill-crests about Akron. The valley consists largely of a series of basins, the hills separating and again approaching the stream. The bottom-lands are good, but much cut up. The staple on them is corn. Back from the river wheat is raised. On the hills is oak, a little beech and maple, and some fir.

Abstract of levels.—Fall from Hiram rapids (head of power) to lake-level is approximately 525 feet, 455 feet between the lake and the upper pond at Cuyahoga Falls and 70 feet above. Nearly 194 feet of the 455 is compressed within 2 miles at Cuyahoga Falls; hence the foot of the falls is 261 feet above the lake. The total fall utilized by manufactories is about 150 feet. There are 43 feet total of old abandoned power, and about 8 feet used by the canal.

The unimproved fall is about 360 feet. Of this, part is poorly located and part is awaiting capital; 120 feet is at Cuyahoga Falls.

DESCRIPTION OF THE WATER-POWERS.

For 3 miles the river is dredged to admit of navigation, and is 100 to 200 feet wide. The Ohio canal is then locked into it. Above, the immediate banks are from 4 to 6 feet high, clay, and vertical, with overhanging sods in many places, showing that the river is eroding them. The bed is mud or gravel and stones. A little below Brocksville is Packsaddle narrows, where the valley is very narrow and there is considerable fall.

Brocksville.—At Brocksville is a pond feeding the canal, with a head of 4 feet. There are no mills. The bed is flat ledge-rock.

Boston.—At Boston is the first dam built below Cuyahoga Falls. It was erected in 1821. A log dam now replaces the old one. It is a spur dam with eight tiers of logs. There is a flour- and grist-mill on the east bank of the river, and a saw-mill is also run by the same power. The bed is rock, and the earth-banks are 7 or 8 feet high. The dam is about 150 feet long, and the pond backs half a mile up stream. Its level is 90 feet above the lake. Below Boston the bed is largely made up of gravelly earth, and this, together with the small volume of flow below the canal dam, makes the powers inferior.

Peninsula.—The town of Peninsula takes its name from the necks formed by the bends of the river. At the upper and principal one the river swept around almost in a circle one-third of a mile in diameter, embracing a flat of about 20 acres. This bend has been cut off by the railroad. The channel returned to within 16 feet of itself, and an old resident said he had seen the two currents rushing in opposite directions in high water, and separated only by a narrow strip of land 2 or 3 feet wide. The neck rose 10 feet above the water, and the difference in the level on the two sides was 6 feet. When the Valley railroad was built, in order to avoid erecting two bridges within less than half a mile distance, the neck was cut down and the river turned abruptly to the west, thus leaving the channel dry. Previously to this the Peninsula flouring-mills, situated right at the neck, had merely thrown a line of logs across the channel, raising the level 1 foot, and thus obtained 7 feet head. The head-race is tunneled through the blue shale. When the neck was cut the head of 7 feet was maintained by merely sinking two sill-pieces into the bed of the river and covering them with planking. The canal crosses the river below the mill by a bridge, and is locked down by a lock of 10 feet lift to the flat. Then it bends to the west and follows the river around the hill, which is part of the "second peninsula". Part way around this hill the canal is fed from the river by a dam with 4 feet rise. Above the "neck" is the upper dam of Peninsula. There are two saw-mills and a planing-mill using the power, which has 8 feet head.

The total fall utilized for power at Peninsula is 15 feet. There is sufficient power for the requirements except on Mondays. The reason of this is that the mills at Cuyahoga Falls and above shut down on Saturdays. There is considerable unimproved power, especially below the neck, where the river falls rapidly, and none of this power is utilized. Just above the railroad bridge at the "third peninsula" there is at least 6 feet fall available. At one time the water was taken across the peninsula by means of a race to a grist-mill at Buttermilk falls, but this is disused. The upper pond at Peninsula is 40 feet above the Boston pond and 130 feet above the lake-level. The bed is firm and rocky to half a mile above Peninsula, but above that to Cuyahoga Falls the bed is poor for dams, and there are no mills on the stream until the latter place is reached, although there is considerable fall.

The Valley Forge property.—The rise from the upper pond at Peninsula to the foot of the Valley Forge property is 67 feet, and there is 25 feet fall now lying idle. In early days iron ore was reduced at the place. The situation is good for dams, and a pond is practicable. The Little Cuyahoga, entering at Akron, is the chief tributary, but is of little importance for water-power.

CUYAHOGA FALLS.

Cuyahoga falls are situated in Summit county, just above where the river takes its bend to the northwest. The drainage area above the village is 328 square miles. In about 2 miles the river falls 194 feet in a succession of rapids and cascades. At the upper part the river flows at the level of the slightly rolling country, and from there it has cut its way down through the sandstone and shale of the Coal Measures, through the conglomerate, and into the Cuyahoga shale of the Waverly. At one time the falls were at the north line of the county, and probably had a vertical fall of 200 feet.

The village of Cuyahoga Falls is at the upper end of the glen. The Cleveland, Zanesville, and Cincinnati railroad passes along the east bank close to the cliffs, which, at the High bridge, rise 100 feet. In the village are five dams, supplying some ten or twelve mills, machine-shops, chain-works, etc., with power. These five levels take 74 feet of the fall, leaving 120 feet of unimproved fall below them. Between the levels there is no unimproved fall of any consequence.

The Millbank property.—Ascending the stream, the first power met above Valley Forge is included in the Millbank property, belonging to Mr. Millbank, a capitalist of New York city. This includes 1½ mile below the Hinds dam, and embraces the wild and beautiful scenery of the falls. At Big falls, 25 feet high, the water tumbles over a succession of sandstone strata underlaid by soft shale. Above Big falls the river is placid for some distance, and makes a graceful sweep around to the northeast, with a heavily wooded flat in the bend of 5 or 8 acres area. Above the bend the slope increases rapidly, the banks approach each other, and huge bowlders and masses of rock obstruct the flow. This reaches the climax at a place called "the gorge", where the passage is so narrowed that the river is literally forced up on edge and foams between the huge rocks with great force. Above this point the channel widens somewhat and the current is less impetuous, although still very rapid. From there up to High bridge the banks, which have been very steep and rocky, rise in bold cliffs, especially on the east side, some 100 feet in height. The rock is the new red sandstone, which would yield a fair quality of building-stone. It is coarser and a lighter brown than the Connecticut brownstone. The cliffs show, also, a section of the Carboniferous conglomerate. A pleasure-resort company has taken possession of the glen.

From the overhanging eastern cliffs 100 feet above, springs of clear sparkling water trickle over in drops which fall like the first drops of a shower into the still, dark basin below; lighted by the afternoon sun they glisten like diamonds. Standing on the hill opposite the bend of the river, a beautiful view is obtained down the valley of the hills wooded from the top to where they meet the river, while up the river is the glen, and the opposite bank is darkened by the heavy hemlock foliage.

From the foot of the Millbank property to Big falls is 40 feet rise, at Big falls 25 feet, and from there to the bend there is a rise of 10 feet. By building a dam 10 feet high at Big falls there would be 35 feet head available, and 265 horse-power during ordinary low water. The power could be transmitted by wire rope to near the railroad, or utilized on the spot if the proposed wagon-road is built. The dam would be not over 150 feet long, and the pond would overflow slightly if at all. From the bend through the gorge the rise is 24 feet, and to the foot of Hinds' dam it is 20 feet more. A short distance above the bend a dam could readily be constructed, but the best place is directly in the gorge, where the position of the rocks is such as to make excellent abutments for the dam, and the power could be transmitted along and up the banks by wire rope. The dam would be not over 50 feet long, and all the fall up to the Hinds level could be utilized. If the Millbank property were fully developed there would be 980 horse-power available with ordinary low water.

The bed of the stream is rocky and firm and the banks are good, as just described, and ponds would not spread. Right at hand is an unlimited supply of good building-stone. The one disadvantage is the inconvenience of access in some places, but even this can be readily overcome. There seems to be no reason why the development of the power should not be attended with success. Mr. Millbank is a wealthy man who has felt no necessity of using the resources of the place, and for this reason, apparently, the power has remained idle.

In the year 1835 a company called the Portage Canal and Manufacturing Company bought a tract of land in the vicinity of Akron with the intention of building up a city, but seemingly with the more immediate intention of selling lots. As an accessory to the scheme the company bought what is now the Millbank property, intending to run the water off by a race 6 miles long to their city, and utilize it there for manufacturing purposes with about 180 feet head. It is now thought that the object was to make a sensation in the midst of which to sell the lots; certain it is that the race as constructed was ridiculously small for the purpose. Where examined near the head, it could not have been over 15 feet wide, and probably averaged less. The dam was built a short distance below the Hinds dam, and the race ran along the east bank in the shale underlying the conglomerate. This shale slacks on exposure and will not hold water. The race as well as the city was a total failure, and the ruined embankment now forms a convenient promenade for pleasure-seekers.

The Hinds level.—The Hinds dam is situated immediately above the Millbank property, and from this point up all the fall is utilized. The dam is a frame 100 feet long, built of triangular sets. From it a flume runs down the west bank, 300 feet long and 6 by 6 feet in section, built of 2-inch pine plank. At its foot is a 35-inch turbine, whose shaft extends 80 feet up the cliff in a vertical "husk" to the flour-mill. The head is 14 feet, and 100 horse-power is available.

Levels above Hinds' dam.—Above Hinds' dam are four levels, with the following heads, in order: 16½ feet, 18 feet, 10 feet, and 15 feet. At these levels there are twelve establishments using 575 horse-power total, according to the census returns. They consist of one flour-mill, two paper-mills, a wire-works, a sewer-pipe manufactory, a bolt- and nut-works, foundery, and machine-shops. Practically, all the available power is taken up, as, with the estimated ordinary low flow of 67 cubic feet per second, the total power is about 450 theoretical horse-power. The dams are like the Hinds dam, except the upper one, which is of peculiar construction. It is built of hewed timber 12 inches square, laid close in two concentric arcs, and keyed together with cross-pieces of scantling 2 feet long. Above this dam there is a stone filling.

Munroe falls.—Munroe falls, 2 miles up stream, is the first available power above Cuyahoga Falls. There is 10 feet head utilized by a paper-mill, which claims 115 horse-power. The dam is an arched timber dam 100 feet long.

Kent.—At Kent is the next available power, and it has 26 feet head. The dam is a nearly semicircular arch of stone 2½ feet thick, and filled in with stone above. The chord is 75 feet. The bed and banks are rocky and the banks high, so that the pond near the dam is scarcely 40 feet wide; it runs back 5 miles. There is a race on each bank. On the right bank is the Kent alpaca mill, using an overshot wheel of 17 feet diameter and 19 feet face, capable of 50 horse-power. On the opposite bank is a flouring-mill, claiming in the census returns 100 horse-power under 21 feet head.

The river above Kent.—Above Kent there are four places at which power is used. At Sheffield there is a grist-mill using 25 horse-power, and a stone- and earthen-ware establishment using 8 horse-power. At Mantua is a grist-mill using 25 horse-power. At Hiram rapids there is an available fall of 10 feet. Above the rapids are two grist-mills using 12 and 30 horse-power under 13 and 14 feet head, respectively.

THE OHIO CANAL FROM CLEVELAND TO THE SUMMIT.

This canal runs from lake Erie to the Ohio at the mouth of the Scioto river. It is in a better condition than the Miami and Erie canal. The first feeding-place above Cleveland is at Seventeen-Mile lock, 17 miles from Cleveland. There are three establishments using power between Cleveland and Peninsula—the Austin Powder Company,

3½ miles up, a flour-mill 14 miles above Cleveland, and a second flour-mill 19 miles above Cleveland. At Akron there are five powers used from the canal by a flouring-mill, a paper-mill, a planing-mill, pump-works, and rubber-works. Beyond the summit level in the Ohio basin there are several mills. The branch running east past Cuyahoga Falls was bought by the railroad and closed up.

THE HYDRAULIC CANAL OF AKRON.

Akron is an extensive manufacturing center, and most of the power used is steam-power; the State canal and this hydraulic canal represent the water-power of the city.

The Hydraulic Canal Company was organized in 1839, consisting of the owners of the five mills now using the power, viz, the Cascade, Etna, City, Allen, and Stone mills. The power is obtained by tapping Springfield and Fritche's lakes, each about 1 mile long by half a mile wide, and carrying the water to the city by a canal. Part of the distance the channel of the Little Cuyahoga is used. Each of the lakes is tapped by a 24-inch pipe running up through the bed, and leading off with about 6 feet fall a distance of nearly 1,300 feet to the canal. Springfield lake can be drawn down 6 feet and the other 8 feet. Although there are these two reservoirs the supply gets low in dry seasons, and several of the mills supplement the power with steam. There are six mills on the canal, all near where it empties into the Ohio canal, but one of them, the Turner mill, now uses steam altogether. All are flouring-mills but the Turner mill, which manufactures oat-meal. Passing down the canal they are as follows: The Stone mill, with 27 feet head and averaging 75 horse-power; the power is unsteady and they use steam. The Turner mill, with 5 feet head, owing to the canal lock (not using water-power now). The Allen mill, with 18 feet head and 43 horse-power; steam is always used to aid the water-power. The City mill, with 25 feet head, and a wheel rated at 100 horse-power; they can run at their full capacity seven or eight months of the year. The Etna mill, with 20 feet fall and a wheel rated at 80 horse-power; they also use a 100 horse-power steam-engine. The Cascade mill, with 28 feet fall. These mills have much more machinery than can be run by the flow available from their drainage area, and it may almost be said that the water-power is used as an auxiliary to the steam-power.

THE GRAND RIVER.

The Chagrin river is a small stream having a few unimportant mills, and the next river to engage attention is the Grand.

This stream rises in Geauga county and flows north to within about 10 miles of lake Erie, and then bends 90 degrees and flows west some 20 miles, entering the lake near Painesville. The drainage area is 690 square miles. The chief tributary is Rock creek, which enters it from the east, about 2 miles above the bend. The river is an instance of the effect of clearing and draining the land; if it were a steady stream its ordinary low flow would probably be at least 50 cubic feet per second, but it has become so flashy as to be almost worthless for water-power. There is considerable fall in places, but sometimes the bed is almost dry. Formerly there were several mills, now mainly discontinued or using steam. The census returns show only three mills on the river, using 60, 60, and 20 horse-power, under 35, 7½, and 8 feet head, respectively. Below Mesopotamia, in Trumbull county, the fall is slight to the bend, and a dam is said to back the water up stream for a distance of 20 miles.

WATER-POWER EAST TO THE NIAGARA RIVER.

There are no streams of much importance for water-power east of the Cuyahoga river to the foot of lake Erie. Ashtabula, Mud, and Cataraugus creeks, etc., are small and of little importance for water-power.

TONAWANDA CREEK.

Tonawanda creek, entering the Niagara river at Tonawanda above the falls, is larger than Cataraugus creek, but is unimportant for water-power, not only on account of its size, but especially because flashy. In early times it was more steady, and there were many small mills on its upper part, but now they are unused. At the mouth is a canal dam giving slack-water navigation for the Erie canal. The head is 4½ feet and the pond is 12 miles long. There is a power 15 miles up the stream at a place called Rapids, but this is within the Indian reservation. At Batavia, also, there is some fall.

THE ERIE CANAL AT BLACK ROCK.

The Erie canal enters Tonawanda creek at Pendleton some 12 miles above the mouth, and then by the slack-water navigation referred to the boats reach Tonawanda. From there a short canal extends along the bank of the Niagara river to Black Rock, about 3 miles below Buffalo, and there it is locked into the Niagara river. At Black Rock there are five good-sized flouring-mills using the power, which has about 5 feet head. The supply of water is constant, but some trouble is experienced, especially by the lower mills, from the water backing up on the wheels, owing to the rise in the river. This is caused by the wind, and is from 2 to 3½ feet, as an extreme.

THE WATER-POWER OF NIAGARA RIVER AND FALLS.

Because of the importance of the Niagara water-power and the great impetus which manufacturing has recently taken at the falls, a second and special visit was made to the place in August, 1882, and the following report relates to the condition of the power at that time:

The system of fresh-water lakes which drains into the Atlantic through the Saint Lawrence river extends half way across the continent to the Pacific, and from the Saint Louis river at the head of lake Superior to the head of the Saint Lawrence, includes thousands of square miles within its basin. The lakes Superior and Michigan drain through lake Huron into lake Erie, and from the latter the combined volume of water pours into lake Ontario through the Niagara river.

The Niagara, with a volume nearly half as great as the Mississippi, has only a short course of 37 miles in a direction of a little west of north; but in order to reach the level of lake Ontario it has to descend 333 feet, and to its immense flood falling all this height within so short a distance is due the grand falls with their rapids. The river makes a vertical plunge of about 160 feet.

GENERAL DESCRIPTION OF THE LOCALITY.

The river forms the boundary between Canada and the state of New York. Between lake Erie and the falls it divides into two channels around Grand island, which is about 10 miles long and 4 or 5 miles wide. In passing around this island the eastern channel bends to the westward, and for the 3 miles from the foot of the island to the falls, the course of the river is west.

At the falls, which are 23 miles below lake Erie, measured along the east channel, the river is divided into two channels by Goat island, which, beginning at the falls, runs up stream 3,000 feet, and is 1,100 to 1,200 feet wide. The rapids begin at the head of Goat island and continue to the falls. The channel on the Canada side forms the Horseshoe falls, 158 feet high and 2,400 feet wide, and the other the American fall, 167 feet high and 1,000 feet wide. One mile above Goat island the river is over 6,000 feet wide. At the head of the island, the American channel is only 500 feet across, and the other channel is 3,200 feet in width, probably taking seven- or eight-tenths of the total flow of the river; hence the Horseshoe fall is much the more important of the two.

Immediately at the falls the river turns directly at right angles and flows north, and here begins the gorge which characterizes it, to the village of Lewiston, 7 miles below, where are the Lewiston heights; the river, emerging from them upon the plain below, flows the remaining 7 or 8 miles to lake Ontario. Just below the falls, the gorge is 1,100 to 1,200 feet wide from brink to brink, and the river is 800 to 900 feet wide. The banks rise in vertical cliffs 210 feet above the water, with a talus at the foot, and the river reaches a maximum depth of 189 feet. Owing to the bend of the river, the gorge may be said to begin at the Horseshoe fall, and the American fall enters over the eastern cliff.

Two miles below the falls are the Whirlpool rapids, where the river contracts to 400 feet in width, and farther below is a point where it is only 300 feet across.

The country through which the Niagara flows may be roughly described as a plateau separated from the low land bordering lake Ontario by the terrace called Lewiston heights, which extends far to the east in the state of New York, and marks an old shore-line of lake Ontario.

When the lake-level lowered and this outlet of lake Erie began to fall over Lewiston heights, it speedily wore its way through the thin covering of drift forming the river terraces now seen along its course, and attacked the layer of Niagara limestone which made its bed. The Niagara limestone is underlaid by a thin stratum of very soft shale, and below this are strata of varying hardness, and the result was, that as the hard rock was undermined by the action of the water it fell and left a constantly receding vertical face over which the river passed.

Gradually the falls receded up stream, varying in height and form as the slight dip of the strata changed the altitude of the hard layers, leaving below the deep narrow gorge, while above, the river flowed at the surface of the country or had only cut shallow terraces through the drift. The present time finds the falls opposite the village of Niagara Falls, 7 miles on their course toward the threatened draining of lake Erie.

Above the falls the river flows over solid rock, which is destined to be broken and ground by the relentless fury of the flood. Its banks are low, scarcely more than clay rim-banks rising above the surface of the water, but as the falls recede the banks will probably form a continuation of the terraces which now border the gorge.

Goat island is a portion of the country which has been left by the river, and will probably continue until the recession of the Horseshoe fall drains the American channel and joins it to the mainland in the far distant future.

The surface of the island, like the shores of the river, is very slightly elevated above the water at the head of the rapids; but while it maintains a level surface the rapid descent of the river makes its sides precipitous bluffs near the falls.

MAP OF
NIAGARA FALLS
Reproduced from the Map of the U.S. Lake Survey.

The Whirlpool rapids are caused by a tendency to a repetition of the circumstances which make the falls; a much harder stratum of rock outcrops in the bed of the river at that place, and hence the channel is not worn so deep, and it is the rush of the great volume of water in endeavoring to pass this shallow place that causes the tremendous surges of the rapids.

POWER OF THE NIAGARA RIVER.

Although it is difficult to imagine that the estimate of the total power of the Niagara river will ever be of practical importance, yet, the data being given, it is a matter of very easy calculation.

According to gaugings made by the United States engineers, the average flow of the river above the falls is found to be 10,000,000 cubic feet per minute, 166,600 cubic feet per second.

The fall of the river in the 20 miles from its head at Buffalo to 3 miles above the falls is 20 feet. From this point to the brink the total fall is 53 feet, of which nearly all is comprised in four terraces of the following heights above the brink of the falls: First terrace, 14.75 feet; second terrace, 24.09 feet; third terrace, 32.42 feet; fourth terrace, 39.79 feet (Blackwell's survey, 1842). Goat island has the same general level as the fourth terrace.

The American fall, according to Blackwell's survey, is 167.7 feet high, and the Horseshoe fall is 158.5 feet high. From the foot of the falls to Lewiston the descent is 98 feet, and from there the surface of the river falls 2 feet to lake Ontario.

The following table gives the theoretical power of the river in falling from one lake to the other:

Portion of river.	Fall in feet.	Theoretical horse-power.
Lake Erie to above the rapids	20	378, 00
The rapids	53	1, 001, 700
The falls	160	3, 024, 100
The falls to Lewiston	98	1, 852, 300
Lewiston to lake Ontario	2	37, 800
Total	333	6, 294, 000

Of this 6,000,000 horse-power, all but about 400,000 is between the head of the rapids and the foot of the gorge, and 4,000,000 horse-power are expended within a distance of less than a mile at the falls.

Fluctuations in flow.—With the immense storage-reservoirs above, the Niagara river is very steady in its flow, but it has been known to vary as much as 33 per cent. in 48 hours; this is due to the wind on lake Erie. If the wind blows strong from the northeast for some time, it lowers the eastern end of the lake, and then if it veers around suddenly into the opposite direction, the maximum flow is observed on the river. The extreme limits of variation in the depth of the river above the falls is 3½ feet, but these limits are very rarely reached; the ordinary variation is hardly more than 1 foot. Below the falls the level varies 15 feet, because of the diminished width of the channel.

Variations in the lake-level.—There are variations in the levels of the lake, and hence in the flow of the Niagara river, which can not be attributed to variation in the rainfall, or to the wind, and are not satisfactorily accounted for. Sudden tides occur, amounting in some instances to 3 or 4 feet in height, and it is claimed that there are periodical changes extending over several years. Mr. Charles Rhodes, of Oswego, New York, in a publication on the subject states:

> In April, 1873, after eighteen months of very low water, lake Ontario rose 2½ feet in about twenty days. When it is considered that the whole inflow of the Niagara during that time would scarcely more than fill the lake to that extent, or if the flow of the Saint Lawrence were entirely stopped for a couple of weeks it would only raise the lake to that extent, the magnitude of the change may be appreciated, but can hardly be accounted for.

He argues against the theory of a subterranean channel between the lakes. Mr. Rhodes is inclined to attribute some of the changes in level to inequality in the atmospheric pressure.

USE OF POWER AT NIAGARA FALLS.

There have been men from the early years of the country who have realized the value of the power, and have anticipated for it an era of usefulness, which is fortunately in no wise incompatible with the much-needed restoration of the natural beauty of the place.

In the year 1678 a portion of one of La Salle's exploring expeditions built their huts some 5 miles above the falls, and there is a description of the impression produced by the falls upon the explorers, written by Father Hennepin, a priest who accompanied the party, and who acted in the capacity of historian.

For nearly a century after this visit of the French there was, so far as can be learned, no attempt made to make use of the water-power, and it was not until 1750 that a wheel was built.

HISTORICAL SKETCH OF THE USE OF THE POWER.

The following is an abstract of the history of the development of the water-power interests of Niagara Falls, as obtained through the courtesy of Mr. Albert Porter, an old resident of the place. In order to make it intelligible it is well to give a brief account of the improvements as they exist at present:

The village of Niagara Falls is situated in the angle at the falls where the river bends; it extends along the New York shore nearly a mile above the falls, and also some distance down the gorge. In 1870 the population was 3,006, and in 1880 it was 3,320. The land on which the village is built is quite level, and the variation in altitude is only about 40 feet. The contour is such that races could be very readily constructed along the rapids, using their fall; but the crowning feature of the place in this respect is that the level nature of the land permits the excavation of canals through the village, across the bend, striking the river bank below the falls. This is precisely what has been done. Starting above the village, at what is called, by some, Port Day, an hydraulic canal passes across the bend, and ends in a basin 600 feet long, running parallel with the cliff 2,400 feet below the American fall. Along this basin mills are situated. There are also two races along the rapids; the upper race, starting opposite the head of Goat island, and the lower race, beginning about half way down the length of the rapids and extending to Prospect park, which occupies the angle immediately at the American fall.

On Bath island, which is in the American channel, a little below the center of the rapids, there is a paper-mill obtaining a head by means of wing-dams; and this concludes the list of developments of the water-power of the falls, with the exception of a wheel used on the Canadian side for pumping water for the inhabitants.

As early as 1688 La Salle built the first stockade at Niagara. In 1725 it was greatly enlarged, the stone buildings now standing were erected, and a permanent fort was made.

The first recorded use of the water-power was the erecting of a saw-mill, probably in 1725, to supply lumber for the use of fort Niagara. This was built just above the site of Witmer's mill, which stands near the head of the upper race. The entire region remained in the hands of the French until the war with England. During the war the mill was destroyed, but was afterward rebuilt by the British when they gained control of the region.

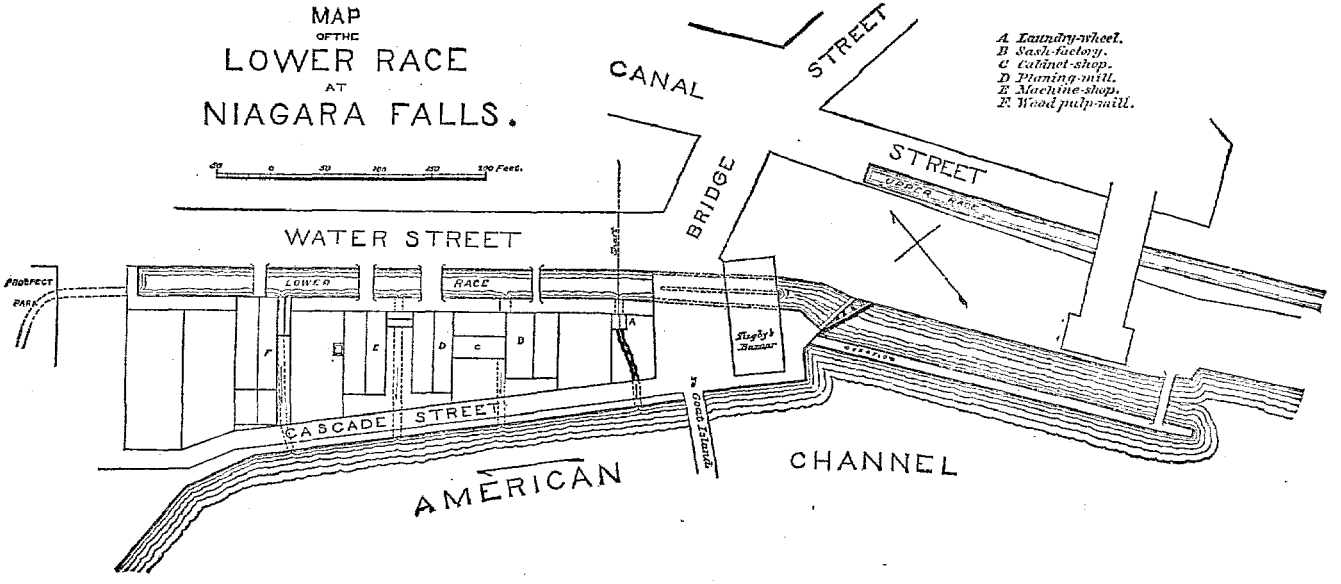
Passing over the intervening time to the present century, during which no further use was made of the power, we find that, through the disputes of the colonies concerning their boundaries, New York finally came into possession of a tract 1 mile wide along the entire length of the east side of the Niagara river. This was surveyed into farms, water-lots, etc., and sold, and Augustus and Peter B. Porter and Benjamin Barton bought a very large tract in the vicinity of Niagara Falls. To a considerable extent this yet remains in the possession of the heirs of Augustus Porter, who had great faith in the value of the place for manufacturing, and gave the village the name of Manchester. He built the upper race in 1805, extending it only a short distance below the site of Witmer's mill, and erected a saw-mill, and the next year a grist-mill was built. About that time was started what has grown to be the present lower race, and from it were run a woolen factory, a carding-mill, and a tannery. In the war of 1812 the village was entirely destroyed, and the power was not again used until 1816. Mr. Porter then rebuilt the grist-mill, placing it just above the site of the Witmer mill, where the old building is still standing. In 1822 he built on a much larger scale, and the building, now known as the Witmer mill, is still in use.

In 1823 a paper-mill was built on the lower race, and three years after was converted to other uses. Various other industries were started on the lower race, a forge, furnace, machine-shop, and pail factory at an early day, and others of more recent date. In 1826 A. H. Porter and H. W. Clark built a larger paper-mill on Bath island, where the industry yet exists, but in other hands.

In 1847 Augustus Porter, after having a survey made, published a proposal inviting capitalists to construct a canal along the site of the present hydraulic canal, estimating that power for sixty run of stone could be obtained with a cost of $30,000. Nothing was accomplished until 1852, when on the 24th of December his heirs—Mr. Porter being deceased—made a contract with Walter Bryant, of Boston, Massachusetts, whereby, on condition of the canal being constructed, there were to be conveyed to him 100 feet right of way for the canal, and 75 acres of mill-sites along the river below the falls. In 1853 Mr. Bryant organized the Niagara Falls Hydraulic Company, with Caleb S. Woodhull, ex-mayor of New York, as president and himself as agent. In 1854 the interests of this company were conveyed to John Miller, and the actual conveyance of the property was made to him by Mr. Porter's heirs.

From John Miller the property passed to Horace H. Day, a prominent eastern manufacturer, and his associates, and by their enterprise the canal was completed as it now exists. Then followed a long era of stagnation in the interests of the water-power, due partly to the distractions of the civil war, and partly to a somewhat visionary management. Finally the property passed into the hands of Mr. A. U. Chesbrough in 1874, and in the next year the first building was erected, a flouring-mill owned by Mr. C. B. Gaskill. Mr. Chesbrough sold his interests to Mr. J. F. Schoellkopf, of Buffalo, and the property is virtually under his control at present. The company is titled the "Niagara Falls Hydraulic Power and Manufacturing Company", of which Mr. Schoellkopf is president.

All the development of manufacturing on the basin has taken place since 1875, and the last three or four years have seen an immense increase. It is easy to see that the development of a most important manufacturing center rests with those capable of comprehending and improving the situation. Evidently the future manufacturing development depends upon the hydraulic canal, so far as existing works are concerned, rather than upon the two


MAP
OF THE
LOWER RACE
AT
NIAGARA FALLS.
A Laundry-wheel.
B Sash-factory.
C Cabinet-shop.
D Planing-mill.
E Machine-shop.
F Wood pulp-mill.
CANAL
STREET
BRIDGE
STREET
WATER STREET
PROSPECT
PARK
LOWER
RACE
CASCADE STREET
Goat Island
AMERICAN
CHANNEL

races, which can never be enlarged to embrace a comprehensive improvement of the river, while the capabilities at the hydraulic basin are unrivaled. So far as can be learned there is no expectation of ever increasing materially the capacity of the races.

Favorable features of the water-power.—It is unnecessary to speak of the advantages of the place as regards unlimited supply of water and steadiness of flow. Winter and summer the river rushes on independent of freezing cold or of the dry heat of the summer months, the greatest variation being due only to the changing direction of the wind. By digging the races deep enough, the only effect of this on the power would be restricted to reducing the almost unlimited head obtainable, by 1, or in extreme cases 2 feet. Ice sometimes occasions trouble at the mills by clogging the racks. With a proper arrangement of breakwaters this is almost entirely warded off.

Regarding freighting facilities, there is the advantage of being on a through line between the West and the East. The New York Central, New York, Lake Erie and Western, Great Western, Canada Southern, and Rome, Watertown and Ogdensburg railroads all have lines to Niagara Falls or close connections.

All the utilized power, except at the basin, is some distance from any railroad track, and the products have to be hauled in wagons, but the tracks of the New York Central Railroad Company pass near the basin, and side-tracks are built there directly to the doors of the mills.

DESCRIPTION OF THE DIFFERENT POWERS.

PAPER-MILL ON BATH ISLAND.

The paper-mill on Bath island has been burnt three times since it was moved from the lower race. The last time occurred in 1881, and it has just been rebuilt in the most perfect manner, fire-proof, and with increased capacity. It produces over 10,000 pounds of printing-paper per day. The bridges connecting the mainland with Goat island touch the island, and the mill and office of the Niagara Falls Paper Manufacturing Company lie just below the road. There are three American turbines under 15 feet head of water, one giving 275 horse-power, and the others 65 horse-power each. This 410 horse-power is all that the size of the building demands.

The head is obtained by means of wing-walls, which extend 500 feet up stream and supply a large amount of water. The head of water does not vary more than 8 inches, depending on the direction of the wind on lake Erie. At the upper end of the wing-walls are several timber cribs sunk in the channel to ward off the ice, and the wing-walls are arranged with an overflow, so that what ice enters the race will pass out into the river. The ice sometimes lodges in the rapids above the opening of the race in blocks nearly 4 feet thick. In the old mill there were thirteen wheels supplied by this race. If the lease allowed the building of a dam to Goat island, and it were desired, the head could be very materially increased. There is no good opportunity for situating other mills on this race.

THE UPPER RACE.

The upper race starts near the head of the American channel, and extends 650 feet down to the waste-weir; from there it continues 800 feet farther, but much diminished in size, with stagnant water at the end of it. The upper portion has existed since 1805, as already described. The only buildings using the water of the race are the Cataract House laundry, near the lower end, and two bath-houses above. The laundry has a 48-inch turbine under 18 feet head of water.

There is a power so intimately connected with the upper race that it is best mentioned here, although to a certain extent independent. Behind the same breakwater which forms the head of the upper race a small race starts along the river-bank, with a stone wing-wall between it and the river, and runs 500 feet down the stream. At the foot is Witmer's grist-mill, with an average head of 6 feet, varying about 8 inches, according to the wind. The mill has four run of stone, and uses 60 to 70 horse-power. Some difficulty is experienced from ice choking the flume. Just above Witmer's mill is an old building which has been occasionally used as a sash-and-blind factory, and has a 60-inch wheel under 4½ feet head of water. A short distance below Witmer's mill is a small wheel at the river-bank, fed directly from the river, and used to pump water to a private residence. The descent of the rapids is so great at that point that a very short wing-wall gives a head of about 4 feet.

THE LOWER RACE.

The lower race is the scene of much more manufacturing than the upper race. It begins just opposite the Cataract house, overlapping the lower 300 feet of the upper race, and runs 1,000 feet along the river-bank. The first 400 feet are formed by a crib wing-wall built in the river; then the race passes through two stone culverts under Tugby's bazaar and the streets to the Goat Island bridge, and finally there is a length of 488 feet to Falls street. From the end of the race a small one, 4 or 5 feet wide and about 1 foot deep, passes under Falls street into Prospect park, and there it supplies 36 horse-power, under 12 feet head, for the electric lights and the inclined plane.

The lower race runs along Water street, and between it and Cascade street, which borders the river, are twenty water-lots, varying from 58 to 132 feet in depth. There are also two lots occupied by Tugby's bazaar. The race is 25 feet wide, and the normal depth is 6 feet. In the wing-wall portion it is about 40 feet wide. The lower 150 feet of

the wing-wall is an overflow, and at the lower end of this are the racks and gates for regulating the flow. All the utilized power is taken below Bridge street, and the buildings are situated on the lots mentioned. Wagons come to the rear from Cascade street, and bridges across the race connect them with Water street. The head of water available varies from about 7 feet at Tugby's building to 17 feet at the foot of the race.

The utilized power is as follows: On lot 2, below the bridge, is a tub-wheel, 6 feet in diameter, under 9 feet head, which furnishes power for the laundry of the International hotel by a 2½-inch shaft 300 feet long. On lots 5 and 6 is a sash factory, using a 5½-feet tub-wheel, under 11 feet head, giving 25 to 30 horse-power. On lots 7 and 8 is a cabinet-shop, using a similar power. Lots 9 and 10 are occupied by a planing-mill, with a turbine, under 12 feet head, giving 40 horse-power; and on lots 11 and 12 is a machine-shop, with about the same power. These two powers make use of the same bulkhead and tail-race. The next two lots are unoccupied, but upon lots 15 and 16 is a wood-pulp mill, the only very extensive industry on the race. It has two turbines, under an available head of 17 feet, and giving 400 horse-power usually. The remaining four lots are unoccupied, except by a hotel and other buildings.

There has been considerable difficulty between the different establishments on the race, owing to its inability to meet the demands upon it. When all the mills are running the head at the foot of the race is drawn down to nearly 14 feet. With its present capacity there is no power available for additional manufacturing, and, as it is, some of the powers owned are not represented at all in those used.

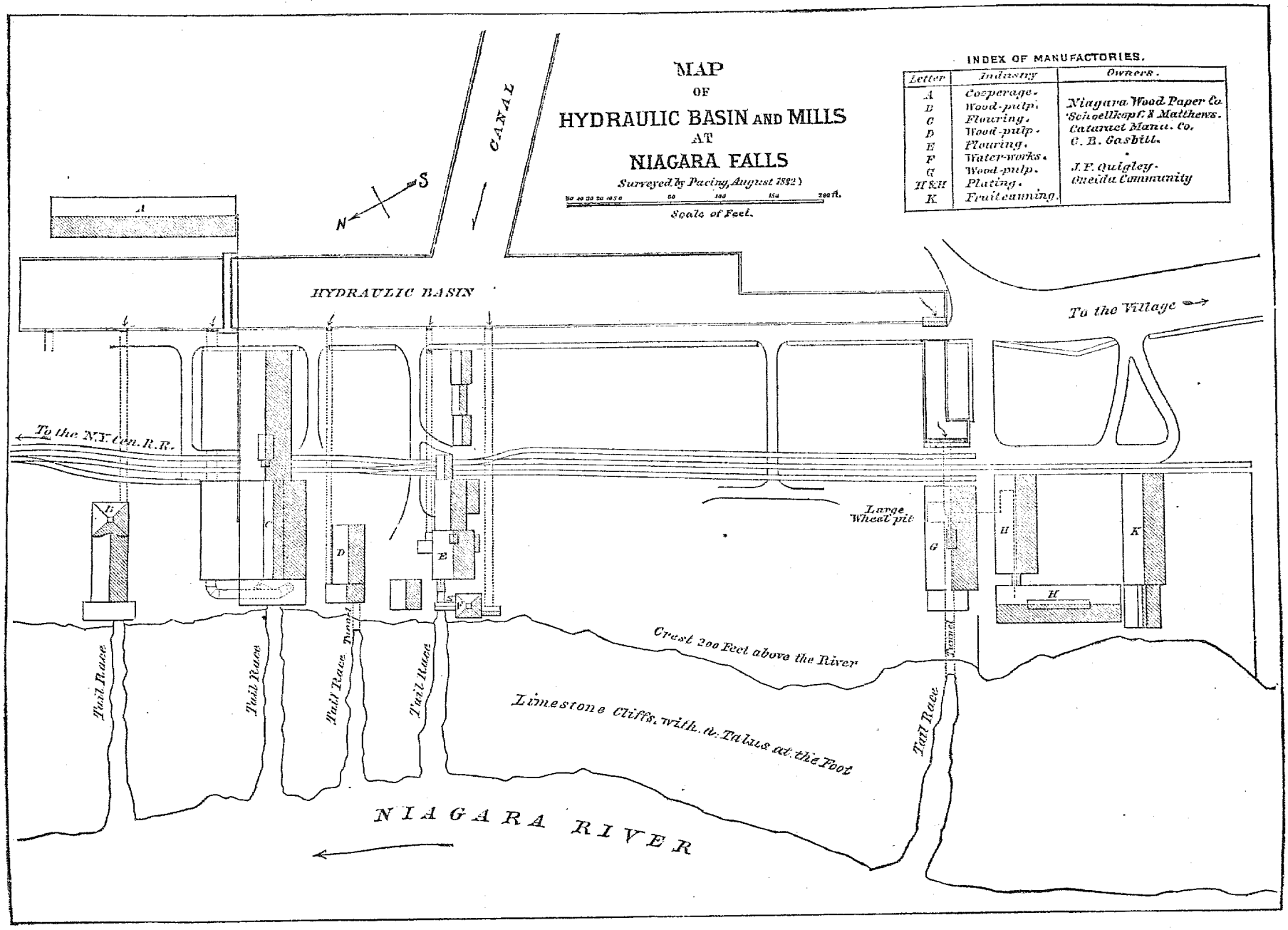
THE HYDRAULIC CANAL AND BASIN.

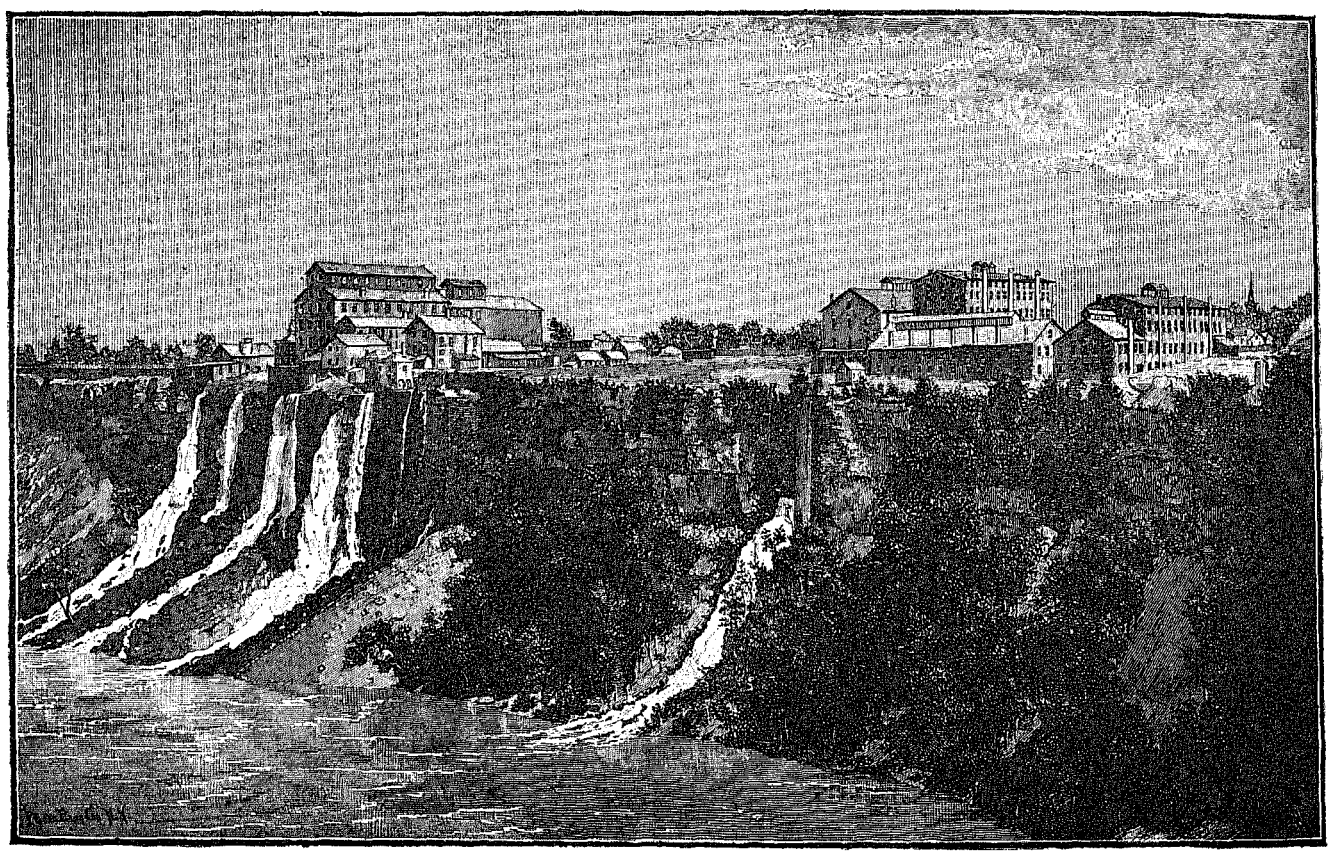
The brief account already given of the hydraulic canal and its history must serve to a certain extent to make its character understood. It is owned by the Niagara Falls Hydraulic Power and Manufacturing Company, of which Mr. J. F. Schoellkopf is president, Mr. Arthur Schoellkopf, secretary, and Mr. Benjamin Rhodes, of Niagara Falls, engineer. The canal occupies the most advantageous position along the river for an extensive development of the power. By cutting across the bend in the river it comes out at the cliff overlooking the gorge, and there is an extensive level tract where manufactories can be erected without interfering with the streets and buildings of the town, where railroad tracks are convenient, and where 210 feet head of water is available. After an inspection of the site it is difficult to conceive of any place more favorable for the development of a great water-power.

Below the covering of from 10 to 20 feet of drift are the solid layers of limestone, which are exposed in section in the sides of the gorge; and the plan pursued is to erect the buildings along the edge, sink a wheel-pit to any desired depth into the rock, and then tunnel out to the face of the cliff for a tail-race. The miniature waterfalls tumbling down the side of the gorge make a really beautiful sight. From the roofs of the mills a stone may be thrown into the river 300 feet below.

By the original grant the company owns 75 acres of land, extending along the river-front, and 100 feet right of way through the town along the line of the canal. The canal when completed did not fulfill the original requirement of 70 feet width, and remains unchanged; part is 70 feet wide, but a portion is excavated only to a width of 30 feet. It is largely cut through the hard limestone, and the deepest excavation is 20 to 25 feet below the surface of the ground. The depth of water is from 8 to 12 feet. The original intention was to furnish a navigable channel with a 30-foot tow-path along the side, but this has not been accomplished. It is practicable, and possibly the future will see boats passing back and forth between lake Erie and the basin in front of the mills. At the entrance to the canal the supply of water is regulated by two guard-locks, placed side by side, one of them usually closed. The length of the canal is 4,400 feet, and at a distance of about 300 feet from the edge of the cliff it enters the hydraulic basin, which is 70 feet wide and runs parallel with the river for a distance of 700 feet. On the level, 300 feet wide, between the basin and the cliff, the mills are situated. A road and sidewalk run along the river side of the basin, and about half way between the basin and the cliff are side-tracks of the New York Central railroad, running nearly parallel with them past all the manufactories. At the south or upper end of the basin there is an extension 30 feet wide for 200 feet, and from the end of this a 20-foot canal passes at right angles 100 feet toward the cliff, where it ends in a bulkhead 40 by 20 feet. All the wheels are set between the railroad and the river, and races run to them from the basin. There are six separate points at which wheels are placed, and some twelve different industries using the power.

Character of lease.—All the power in use is leased, with the exception of the power used by Mr. Schoellkopf, and two powers which were bought in the early days of the improvement. Because of the expense attending the excavating of separate races and tunnels for each mill, and thus to some extent deterring manufacturers from investing, the company has inaugurated the plan of excavating a large wheel-pit and tunnel as a center of power, around which to cluster industries, the shafts of the different buildings gearing upon the main shaft. One has already been made at the upper end of the basin. The company maintains the water-wheels and main shafting in running order, and manufacturers connect their machinery with it. In arrangements of this kind the charge is $10 per horse-power per annum. When heavy powers are required of from 500 to 1,000 horse-power, or more, the manufacturers supply their own water-wheels and appliances, and the company leases out the water under a head of 75 feet, charging $7 per horse-power for all powers up to 1,000 horse-power, and diminishing the rate for larger powers.


MAP
OF
HYDRAULIC BASIN AND MILLS
AT
NIAGARA FALLS
Surveyed by Pacing, August 1882
Scale of Feet.
INDEX OF MANUFACTORIES.
Letter | Industry | Owners.
A | Cooperage. | Niagara Wood Paper Co.
B | Wood-pulp. | Schoellkopf & Matthews.
C | Flouring. | Cataract Manu. Co.
D | Wood-pulp. | C. B. Gasbill.
E | Flouring. | J. F. Quigley.
F | Water-works. | Oneida Community
G | Wood-pulp. |
H&H | Plating. |
K | Fruit canning. |
CANAL
N
S
HYDRAULIC BASIN
To the Village
To the N.Y. Cen. R.R.
Large Wheat pit
Tail Race
Tail Race
Tail Race
Tail Race
Tail Race
Crest 200 Feet above the River
Limestone Cliffs, with a Talus at the Foot
NIAGARA RIVER



Character of the power.—As regards steadiness of the power, there is no reason for any fluctuation beyond that due to the direction of the wind on lake Erie. The running of all the wheels can not lower the level of the basin more than 6 inches, and with the great head used this is of no consequence. Mr. Arthur Schoellkopf states that he does not believe that in their large flouring-mill, which has been running since 1878, there have been twenty-four hours lost from lack of water. The total amount of power which the present wheels are capable of supplying is 4,000 horse-power; and with the large head used this makes little demand upon the basin, leaving a large supply yet to draw upon. By enlarging the canal this can be immensely increased, and the company claims 70,000 horse-power available from their rights. Anchor-ice getting into the racks has occasionally given trouble for a few hours at a time, but is nothing serious, and by having deep racks may be entirely avoided.

Account of the manufactories.—Starting at the lower end of the basin and going toward the falls, the first thing met is an unfinished race and head-gate, which was intended for a compressed-air company, but was abandoned.

Next is the stone building of the Niagara Falls Wood Paper Company, which at present manufactures wood-pulp only. The water passes through a tube and stand-pipe 5 feet in diameter, and turns a 40-inch Lessner wheel, under 50 feet head. The tail-race is an open cut in the bank. The wheel has a capacity of 250 horse-power, but only 230 are in use.

About 70 feet from the wood-pulp mill is the large flouring-mill of Schoellkopf & Matthews. The total area covered by the building is about 225 feet long, by 90 feet wide, and the capacity is 1,000 barrels of flour per day.

The power is obtained by two American turbines, 52 and 32 inches in diameter, respectively, under 50 feet head. They can work up to 1,200 horse-power, but only 800 to 900 are in use. The water passes to the wheels through a heavy boiler-plate stand-pipe, 9 feet in diameter, with a Y-branch to the wheels. The tail-race is an open cut, about 40 feet long, through the bank. The railroad tracks pass through the center of the building.

From the flouring-mill a wire rope transmits power across the basin to a cooper-shop, supplying barrels, and a manufactory of rustic work on the second floor.

Just above the flouring-mill is a stone wood-pulp mill, controlled by the Cataract Manufacturing Company. The wheel is a 48-inch American turbine, under a head of 84 feet. Great difficulty has been experienced in getting one of sufficient strength. It is probable, that to make wheels satisfactory, under such great pressure, bronze will have to be used in their construction. The wheel-pit was excavated 8 feet in diameter, through the limestone, at a distance of 40 feet from the cliff, and then a 6-foot tunnel was run out to the cliff for a tail-race. The wheel is set in the bottom of the pit; and the 4½-inch steel shaft rises through the center, braced at intervals from the rock sides. The power available is 1,300 horse-power, but only about 700 horse-power is in use. There is a small frame shop adjoining the mill, used in connection with it.

About 60 feet beyond the pulp-mill is Mr. Gaskill's stone flouring-mill, the first building erected at the power. There is a 48-inch turbine, under 23 feet head, supplying 100 horse-power. From 30 to 50 horse-power are also obtained by means of shafting from a wheel set at the water-works, between the mill and the cliff. The tail-race is an open cut.

Between the Gaskill mill and the edge of the cliff are the water-works supplying the villages of Suspension Bridge and Niagara Falls. The Holly system of pumps is used, with a daily capacity of 1,500,000 gallons. The water is usually pumped from the river, but can be taken from the basin if necessary. The water-wheel is a 54-inch American turbine, set over the tail-race of the Gaskill mill, under 26 feet head. It is fed through a boiler-plate pipe 4 feet in diameter. About 40 horse-power is used for the pumps.

Beyond the flouring-mill just described there is a vacant space of 450 feet up to the large pen-stock constructed by the company. About this are located several industries started in 1881–'82, as the power was not completed before that time. At the end of the 30-foot extension of the basin and the 20-foot canal is a bulkhead 40 by 20 feet and 20 feet deep. In addition to the gates at the end of the basin extension there are two at this bulkhead designed by Mr. Rhodes, with very powerful screw-gearing, so as to work readily under the 20-foot head. In front of these is a fine rack, constructed of 2½-inch iron bars ¼ inch thick, and kept about 1 inch apart by distance pieces. Behind the gates is a masonry wall, with three openings for the entrance of boiler-plate tubes 7 feet in diameter, which are intended to supply water to three wheels. Of these only the center one is yet in place, but the other tubes and wheels are to be arranged in precisely the same manner as this. From the bulkhead the tubes pass horizontally for a distance of 60 feet toward the river, 20 feet below the surface of the water. There they reach the wheel-pit, which is 40 by 20 feet and 86 feet deep below the water-surface. Falling 56 feet, the tubes reach a shelf cut in the rock 15 feet above the bottom of the pit, and then drop 11 feet farther to the wheels, which are 6 feet above the bottom. From the wheel-pit a tail-race tunnel 6 by 10 feet in cross-section leads 160 feet to the face of the cliff. The wheel now working is a Risdon turbine, 50 inches in diameter, and under the 80 feet head it gives theoretically 1,076 horse-power, transmitted by a 6-inch steel shaft to the gearing above; it requires 8,370 cubic feet of water per minute, and makes 254 revolutions in that time. It is proposed to put in similar wheels at the other two places, when 3,200 horse-power will be obtained.

The power now obtained is leased by the company, under conditions already mentioned, to five separate industries. At the wheel-pit, and continued over it so as to form a wheel-house, is a fine stone building, the back

of which is a wood-pulp mill owned by Mr. J. F. Quingley. The part over the wheel-pit is owned by the company, and in the basement are the two electrical machines of the Brush Electric Light and Power Company, of Niagara, of which Mr. Benjamin Rhodes is secretary. This company has about 4 miles' length of circuit and forty lights.

Just beyond the mill are the buildings of the Oneida community, which has removed its machinery, etc., from Wallingford, Connecticut. The first building and one extending parallel with the river-bank belong to their extensive plating factory, and the one forming the other side of the hollow square has been erected for a fruit-canning establishment. These, in addition to a machine-shop running with wire rope, are all the industries at present using the large power. The smaller shafts gear upon the main shaft from the wheel by means of conical friction clutches.

It is probable that the two remaining wheels will soon be placed in position, as there is already demand for more power. There is scarcely room in the immediate vicinity of the wheel-pit for using 3,000 horse-power, and it will probably need to be conveyed by shafting or wire rope for a short distance.

This concludes the enumeration of the industries on the basin; and it must be evident that, notwithstanding the large amount of power already in use, scarcely an impression has been made upon the possibilities afforded.

UNIMPROVED POWER OF THE NIAGARA RIVER.

The total theoretical power of the Niagara river has been calculated to be 6,294,000 horse-power, and leaving out that above the rapids and below Lewiston, there remains 5,878,100 theoretical horse-power, which in a certain sense may be considered available, although the idea of harnessing the Niagara is a rather formidable one. The total power which the wheels now in use are capable of supplying is about 5,200 horse-power, and the river offers power sufficient to run 1,100 such manufacturing centers as that at Niagara Falls village, and still leave a surplus of water.

USE OF POWER VERSUS NATURAL SCENERY.

But in discussing the development of the power it will be well not to forget the fact that Niagara is one of the grandest sights of North America, visited by thousands, and worthy of all endeavor to maintain it and its surroundings, so far as possible, with the beauty nature once bestowed. The extensive development of the water-power by either country concerned would be a poor investment, unless with it could be preserved the rush and roar of the waters and the wooded shores. It is possible to make an extensive use of the power without interfering with the beauty of the place, as will presently be seen; and the hydraulic canal and basin do not seriously interfere, because, to a certain extent, removed from the vicinity of the falls; but the two races, with their buildings and stone walls, and also the bazaars and hotels along the shore, certainly are not an improvement on the wild wooded banks which once hemmed the river. Nor can any thing be said in favor of the stores and paper-mill on Bath island, which, although a neat stone building, is not in accord with nature's scenery. The rapid destruction of the natural beauty of the place has long excited apprehension, and an endeavor was made in 1880 to pass a bill in the New York legislature for the establishment of an international park, with the aid of the Canadian authorities. The bill contemplated the purchase of the land bordering the river in the vicinity of the falls, the removal of the buildings, and the restoration of the shores to their natural condition. A report of the state survey, published at the time, sets forth the present condition of the place, and contains views of the river as it would appear with the proposed improvements, but nothing has yet been accomplished.

GOAT ISLAND.

After the preceding remarks, it seems an ungracious task to report the existence of valuable powers, in direct antagonism to the restoration of the scenery. Not to mention the Canadian side, where a fine water-power might be created, there is Goat island, whose surface is on a level with the head of the rapids. The distance of the surface from the water gradually increases, so that at the foot of the island it is about 50 feet above the water.

There is every opportunity for starting one or more canals at the head of the island, and running these down stream 3,000 feet; 50 feet head can be obtained, with extensive mill-sites. By excavating a tail-race tunnel out to the face of the cliff, 200 feet head can be obtained. If a smaller power is required, there are the Three Sister islands, which lie side by side from Goat island toward the Canadian shore.

In each of the three channels a large body of water rushes, which can be utilized, but the largest is in the middle channel, where there is a descent of 15 feet or more, and a stream about 40 feet wide, 3 feet deep, and exceedingly rapid.

THE AMERICAN SHORE.

On the American shore the two races could be greatly enlarged with a sufficient expense, and there is also a fine power available by running a canal through Prospect park from above the falls. For such a canal, about 170 feet head would be available.

Distribution of the power in the form of electricity.—There have been numerous schemes proposed for utilizing the power of the falls in compressing air or generating electricity for light and power at a distance. This is not a physical impossibility, and Sir William Thompson is credited with the statement that he "looked forward to the

falls of Niagara being extensively used for the production of light and mechanical power over a large part of North America", and that a copper wire, half an inch in diameter, would transmit 21,000 horse-power from Niagara to Montreal, Boston, New York, or Philadelphia.

A great disadvantage of this method of transmission appears to be that, as yet, there is an immense loss of efficiency experienced in the transition of the electricity into power. The Brush Electric Light and Power Company, of Niagara, is considering the plan of extending its circuit to Buffalo, and in this case the disadvantage would not be so apparent, as whatever was realized from the use of the electricity for power during daylight would be so much clear gain.

In other schemes that have been devised, results have been anticipated at least commensurate with the fullest utilizing of the whole power of the river.

Leaving now the sites in the immediate vicinity of the village of Niagara Falls, there are yet immense capabilities undeveloped along the American side of the river.

From the condition of the hydraulic basin it is seen that only a very small part of the available power is used, and that every thing is ready for an immediate application of great power.

The cliff that bounds the river at the basin extends all the way down to the end of the gorge at Lewiston, and there is no physical reason why the canal should not be extended and mills built all along the river.

There was a bill passed by the legislature of New York in 1853 for the construction of a ship-canal around the falls to lake Ontario; but, owing to the war, attention was taken from the project, and nothing has been done. In connection with it was a scheme for utilizing the water for power at Lewiston heights. Mills were to be built along the heights, tier above tier, and the water was to be carried to them, the tail-race of one becoming the head-race of the one below, until a great manufacturing city was built up.

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AND THE

WATER-POWER OF THE NIAGARA RIVER.