THE NIAGARA FALLS ELECTRICAL HANDBOOK

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THE NIAGARA FALLS ELECTRICAL HAND BOOK

MEMORANDUM.

This electrical handbook is one of a series of ten similar handbooks prepared under the auspices of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS by the local Reception Committees in the Cities of Boston, New York, Schenectady, Montreal, Niagara Falls, Chicago, St. Louis, Pittsburg, Washington, and Philadelphia. These are the stopping places on the circular tour organized by the INSTITUTE for the reception and entertainment of its foreign guests who visit the United States in connection with the International Electrical Congress at St. Louis, September 12th to 17th, 1904. It is hoped in these handbooks to present short historical sketches of the cities visited and a rapid survey of the power plants and important electrical industries along the route.

Niagara Falls. **No. 316**

Compliments of

LOCAL RECEPTION COMMITTEE

BOSTON MASS.

THE NIAGARA FALLS ELECTRICAL HANDBOOK

[American institute of electrical engineers]

THE NIAGARA FALLS ELECTRICAL HANDBOOK

Being a Guide for Visitors from Abroad Attending the International Electrical Congress, St. Louis, Mo. September, 1904

Niagara Falls

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PART I

NIAGARA

The American Falls

Niagara

THE Niagara Region, by which title the inland-stretching banks of our river, from Erie to Ontario, are known to man, touches the history of many persons, of many inventions, and of many branches of universal knowledge, at many points.

In the records of the American Indian, of France, of Great Britain, of Canada, and of the United States,

> "Its name is on their pages,
> And you cannot blot it out."

Its narrative is "history," in the broadest and best sense; for it tells, not only of "wars and rumors of wars," but also of the religions, of the civilization, of the arts of peace, and of the progress of many peoples.

It dates back, in Indian tradition, to the remotest past; and in Indian story, for years before a white man trod its soil.

Its name is writ large in the Indian Missions of the Roman Catholic Church, and in the service of her priests under the flag bearing the lilies of France.

It has acknowledged, on its eastern shore, the sovereignty, in turn, of three of the great nations of the modern world; and on its western shore, of two of them.

It has seen battles, some of undying fame, and decisive of the ownership of vast areas, perhaps of the continent, fought within its limits.

Many times and long has diplomacy exerted all of its arts and of its abilities for its acquisition.

It has played a not unimportant part in the westward extension of civilization and of settlement.

Its name is linked with that of commerce, both on land and water.

It is associated with the sciences, in several paths.

It is prominent, through its reproductions, in the illustrative; and through its achievements, in the mechanical arts.

Its scenic grandeur, and the actions of two sovereign commonwealths, in preserving the surroundings of its main glory for all time for the free use of all mankind, are known of all men.

And, in the literature of the world, and in many tongues, it holds a by no means inconspicuous place.

Indian tradition tells that the aborigines were wont to gaze in awe upon the spray of the Falls, as being the abode of the Great Spirit of Niagara, whom the tribes, from far and near, worshiped; and to whom they offered as sacrifices, by casting into the waters, weapons of the braves, for success in war and in the chase; and fruits of the earth, for the abundance of the crops. In still higher homage, in propitiation of His favor to their race, they annually sacrificed the fairest maiden of the nation, chosen by lot; sending her over the Falls in a white canoe bedecked with fruits and flowers. After death the chiefs were laid to rest on Goat Island, which "none but brave men e'er could reach," and which has been called the "most interesting spot in all America." In later days the Neuter

Hennepin's View of the Falls

Nation held sway over this region, until obliterated, about 1651, by the savage Senecas, who remained "lords of the soil," even under French occupation, until compelled to cede it to Britain, in 1764, as payment for past hostilities.

Priests of the Catholic Church, who daily risked their lives as they carried the Gospel to the Indian tribes in an unknown wilderness, were here during the seventeenth century. In 1626, Father Daillon crossed its stream, "the great river of the Neutrals;" and others, between that date and 1679, when Hennepin and his Brother Recollets, who accompanied the explorer La Salle, stood upon its banks. It is to Father Hennepin that the world owes the earliest description of the Falls, and the first picture thereof. While Champlain, who never saw them, made the first reference to them in literature, just three centuries ago, and Father Ragueneau, in 1648, wrote of this "cataract of fearful height," it is Hennepin's "great and prodigious cadence of waters, which falls down after a surprising and astonishing manner, insomuch that the universe does not afford its parallel," that remains even until to-day as the quaintest and best known of all descriptions thereof.

Wars have raged and bloody battles have been fought upon its soil; the earliest of record, when the Senecas suddenly fell upon the inhabitants of a Neuter village and annihilated them. In after years their winter's siege of Fort De Nonville almost annihilated the garrison, and later compelled its demolition, and the withdrawal of the French.

In 1759, the thrice-projected British attack on Fort Niagara took form, and an army laid siege to it. A few days of cannonading, with the advantage all on the side of the besiegers, and the relieving force, consisting of all the Frenchmen and Indians that could be hastily gathered in the West, reached it. Sir William Johnson, with his forces in battle array, met and routed them. The fort surrendered and Britain's long dream of its possession was at last fulfilled. Four years later, Pontiac's Great Conspiracy touched this frontier, in the Devil's

Hole Massacre; where the Senecas, still friendly to France, ambushed first a British supply train, and then the force that hurried to its assistance; nearly one hundred scalped corpses testifying to the precision of their plan and to the exactness of its execution.

The control of the Niagara Region engaged the attention of the diplomats of both France and Britain for many years; from 1680 to 1725, its acquisition was one of the main features of the policies of those governments. France secured it, but Britain promptly compassed her withdrawal. Years afterwards France again acquired it, and held it, in spite of all her rival's threats and wiles. Then began the plannings; on one side to hold it, on the other to oust its possessor. When diplomacy and intrigue had failed, arms were resorted to; and then Britain won. Her diplomacy failed again in dealing with her American Colonies. To arms again; but this time Britain lost. The Revolution robbed her of all her American possessions, save what she had torn from France; and even of one-half of what she had thus gained along this river. Even then Britain's diplomacy did not despair. For thirteen years, 1783 to 1796, known in history as the "Hold Over Period," she held five of our forts, Niagara the most important. Only on her evacuation of that fort was the tangible hope of some day reconquering her rebellious Colonies dismissed. Indeed, not until the close of the War of 1812 was it really abandoned.

The region has played its part, and an important one, in the extension of civilization and in the settlement of the West. It was the great highway between the Atlantic seaboard and the Mississippi. By its famous portage lay the westward route for all. Under French rule it was secure; her soldiers were there, and Frenchmen were on terms of amity with the Western Indian tribes. Under Great Britain it was also the favored route. But it lay in the Senecas' country, and they were hostile at heart. So it was fortified. There was a fort at its lower end; between that and the river above the Falls, a distance of seven miles, were eleven block houses, garri-

Niagara Falls. From Hennepin's View.

soned and cannoned; at its upper end was Fort Schlosser. It was the best protected highway in all America. Over it passed an enormous traffic, the trade of half a continent; consisting of boats for the soldiers and trappers on their way to and from Detroit and even points beyond, ammunition and stores of every description for the western posts, and loads of cheap merchandise, to be exchanged by the traders for valuable furs. With these cargoes went the different classes of men, who thus taught the savages the ways of their white brethren.

Eastward, over the portage, came a steady stream of peltries, gathered over a boundless territory, en route from Detroit, the western metropolis of the fur trade, to New York. Had there been no Niagara Portage—it was secure and it was easy, for by it there was an otherwise unbroken water trip between Oswego and the western end of Lake Superior—the history of the fur trade, and of its semi-settlement of the West, would have told of greater hardships and of slower growth.

Its name is linked with the commerce of the continent. Niagara, in all its summer beauty, lies spread out before our eyes. One beholds it all, and is thankful. Each time that one views it some new attribute appears. It is, in very truth, "The emblem of God's majesty on earth." Many gifted men and women have tried to record their impressions of it. Has any one of them ever been successful? One of the best, probably the shortest, possibly the most eloquent, certainly the most non-descriptive, was that by Fanny Kemble, who merely wrote: "I lifted up mine eyes, and beheld Niagara—Oh, God! Who can describe that sight?"

On account of its scenery this region has played a prominent part in the general literature of the world. It touches it at many points. In poetry, Niagara is not unnamed. In prose, and in many tongues, in works descriptive, scientific, reminiscent (especially of travel), it is a component element; even in fiction it is not neglected. A bibliography of Niagara is neither uninteresting nor uninstructive; neither is it short.

The modern history of the Niagara Region began with the primitive Red Man. It ends to-day with the progressive descendant of the colonist. At the borders of the cataract, as almost everywhere, the civilization and progress of the latter have swept away every vestige of aboriginal occupation. For the heel of the Anglo-Saxon is on the grave of the Indian, and on his dwelling —by "The Thunder of the Waters."

THE NAME NIAGARA

The word Niagara is a household word the world over, and is the synonym for the typical waterfall. It is of Indian origin. Over fifty variations of the name are known, though for over 200 years the present spelling has been general, and for the past 150 years in almost universal use. Older forms found in books of the seventeenth century are: Onguiaarha, Ongiara, Ochniagara, Iagara, and Niah-gah-ra, the latter accented sometimes on the second syllable. In the more modern Indian dialect the sound of every vowel being always given in full, Ni-ah-gah-rah seems to have been the accepted pronunciation, and is no doubt the really correct accentuation. The modern word Ni-ag-a-ra, accented on the second syllable, is the now invariably-used form of the word; but it is of more recent origin and devoid of the beautiful flowing articulation of the Indian tongue.

As to the meaning of the word there is great doubt. The commonly accepted interpretation, "The Thunderer of the Waters," is the most poetic.

Niagara appears to have been the name of a tribe, given by Drake as "Nicaragas," with the added note, "once about Machilimakinak, joined the Iroquois about 1723." This statement would seem to show that these Nicaragas were a portion of the Neuters (who were conquered by the Senecas in 1651); this remnant then escaping to the Northwest, and that seventy years later their descendants returned and joined the Iroquois, among whom the other survivors of the Neuters had previously been absorbed.

It was the Indian custom to name their tribes and the smaller subdivisions thereof from the most important

The Whirlpool

natural feature of the country they inhabited, or to give their natal name to such feature. So the deduction is that the subdivision of the Neuters who dwelt along the Niagara River took their name from it and its famed cataract. Certainly, these were the chief natural features of the territory, and their principal village, situated just below the end of the lower rapids, and under Lewiston heights, bore the same name, for it was called Onguiaahra. The Neuters are referred to by Father L'Allement in the "Jesuit Relation" of 1641, published in 1642, as "the Neuter Nation, Onguiaahra, having the same name as the river."

THE NIAGARA RIVER

The Niagara, one of the world's shortest, but also one of its most famous, rivers is thirty-six miles long, twenty-two-miles from Lake Erie to the Falls, and fourteen miles from the Falls to Lake Ontario.

Its sources are the basins of the four great upper lakes, whose watershed is over 150,000 square miles. The size and depth of these lakes are:

Superior...365	miles	long,	160	miles	wide,	1,030	feet	deep
Huron 200	"	"	100	"	"	1,000	"	"
Michigan ..320	"	"	70	"	"	1,000	"	"
Erie 290	"	"	65	"	"	84	"	"

The deepest channel from Lake Erie to the Falls, along the centre of which runs the boundary line between the United States and Canada—as determined under the treaty of Ghent, which ended the war of 1812—lies to the west of Grand Island and to the east and south of Navy Island, with an average depth of twenty feet of water. Below the Falls, and extending down to near the cantilever bridge, the depth is 200 feet, as determined by United States Government surveys. Under the railroad bridges the depth is only about ninety feet. In the Whirlpool Rapids, as calculated, it is only forty feet. The depth of the Whirlpool is estimated at 400 feet. From there to Lewiston, it is estimated at sixty feet in places; and from Lewiston to Lake Ontario at over 100 feet.

It is a little less than one-half of a mile wide at its source, one mile just above the Falls, one-eighth of a mile above and at the outlet of the Whirlpool, and only about one-sixteenth at its narrowest point, at Foster's Flats in the Gorge.

From the outlet of Lake Ontario to the ocean, the river is called the St. Lawrence; which name one hundred years ago, was commonly given to what we now call the Niagara River.

The descent of the Niagara River, from lake to lake, is 336 feet, of which 216 feet is in the rapids above the Falls and in the Falls themselves, distributed as follows:

	Feet
From Lake Erie to the beginning of the rapids, (21½ miles,) the descent is	15
In the half mile of rapids above the Falls	55
In the Falls	161
From the Falls to Lewiston (7 miles)	98
From Lewiston to Lake Ontario (7 miles)	7
	336

Below the Falls there is said to be an undercurrent of far greater strength and velocity than the surface current, and to this is attributed the fact that bodies going over the Horseshoe Fall are not usually seen until they reach the Whirlpool.

The river is one of comparatively changeless volume. When for brief periods the water is high a rise of one foot in the river above the Falls means a rise of sixteen feet directly below—caused by the abrupt turn of the river's channel at the Falls and the reduced width from about a mile at the beginning of the rapids above to about a quarter of a mile at the base of the Horseshoe or Canadian Fall.

THE FALLS

Although there are waterfalls that are higher, Niagara, the ideal waterfall, is the greatest in the amount of water that pours over its brink as well as in the impression of immensity it creates. Niagara is deceptive in its height. Viewed from above, either on the American or

Canadian shore, or on Goat Island, one does not appreciate its altitude; but from below, at any point near the falling sheet, one begins to comprehend its immensity.

The approach to most falls is from below, and we get an idea of them as of rivers pitching down to the plains from the brow of a hill or mountain; but at Niagara the first view is always from the level of the upper river, or from a point above the Falls. The Falls are in latitude 43° 6′ west, longitude 2° 5′ west from Washington; or longitude 79° 5′ west from Greenwich.

Goat Island Bridge

The height of the Canadian Fall, over which flows about seven-eighths of the entire volume of water, is 159 feet.

The height of the American Fall is 165 feet, or about six feet greater than that of the Horseshoe Fall, the difference in levels being caused by the greater declivity in the bed of the river in the Canadian channel.

The Canadian Fall is about 3,000 feet in width along the brink; the American Fall about 1,100 feet; and the Goat Island cliff along the gorge is about 1,200 feet in length.

The estimated volume of the Falls in horse power is about 3,000,000; in tons, 5,000,000 per hour, or about one cubic mile of water per week.

The top of the column of spray that is ever rising from the gorge can be seen on a clear day for a great distance, while the roar of the Falls, it has been claimed, has been heard for many miles, doubtless when the section was a comparatively unbroken wilderness.

In connection with the roar of the Falls, it is interesting to relate that, in 1897, a huge telephone transmitter was placed at the entrance to the Cave of the Winds (the other end of the American Fall was tried, but the results obtained were not as satisfactory), and each evening, between 7 and 10 o'clock, for a period of a month, the wire connecting this receiver with the local telephone office was put in direct connection, over the wires of the Telephone Company, with New York city, and hundreds of people listened to the roar of Niagara, 450 miles away; and at the same time power was nightly transmitted from the Niagara Power House over an ordinary telegraph wire to the same room in New York city, and there illuminated electric lamps and furnished current (less than half a horse power) to operate a miniature model of the power house itself and of the adjacent territory.

The apex of the Horseshoe Fall, which is the point of the cataract's greatest erosion, has within the memory of men now living, receded much more than 100 feet.

Hennepin speaks of, and his picture of Niagara (the first one known), published in 1697, shows a third fall, at Table Rock. It seems to be true, as gathered from records, that at that time a large rock, situated near the western edge of the Canadian Fall, created a third fall as the water coursed around it; but this rock has long since disappeared, disintegrated by the elements and its fragments washed away by the stream.

THE FALLS FIRST SEEN BY WHITE MEN

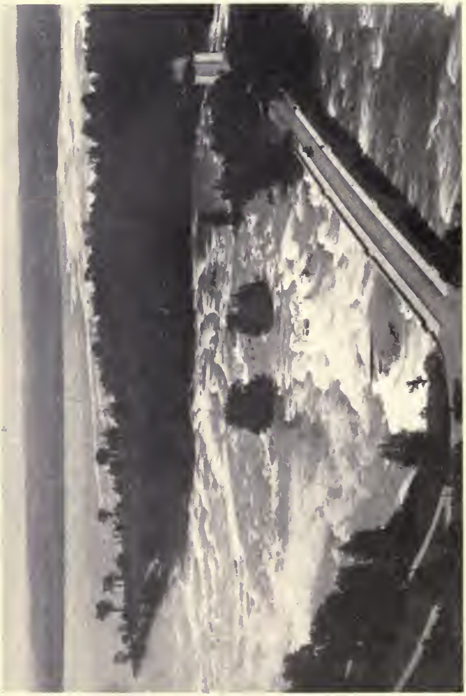
It would be most interesting if we could know the name and nationality of the first white man who ever gazed upon Niagara and the exact date of his visit. According to a legend, the first white man to behold the Falls was a French priest, who was led one moonlight night by an Indian chief to Table Rock. When the chief pointed to Goat Island and said it was the abode of the Great Spirit and that no one except warriors could reach it alive, the priest denounced the statement as false. The chief offered to test this priest's belief by taking him at once to the island, and the priest agreed. The chief led him up-stream to a point above the head of the rapids, where they embarked in a canoe and soon reached the island, on which the priest stepped, and after worshiping his Maker, demanded the fulfillment of the chieftain's promise to become a follower of God if the priest trod the isle alive. The chief demanded a further proof, namely, that he leave the priest on the island alive, and if when he returned the next noon he found him alive he would believe in his God. The priest agreed, only asking that he wait twenty-four hours, and that the next day at sunset he and his tribe should go to Table Rock. At that time he (the priest) would stand on the island's shore at the end of the big Fall. When they saw that he was alive, if they would become followers of God, they should kneel, and across the gorge he would bless them. The chief paddled his bark canoe swiftly up-stream.

The next evening, at sunset, the priest went to the edge of the Fall, and the Indians, who were on Table Rock, seeing that he still lived, knelt down and the priest

"Spake the word,
Though it was not heard,
And raised his hands,
As God commands,
And lifted his eyes to Heaven.
Thus in the way the church decrees,
To supplicants, tho' afar, on their knees,
Was the Benediction given."

Then the priest, so runs the legend, in imagination again stood in a holy church, for

"It was three long years since he
Had stept within a sacristy,



Birdseye View of Upper Rapids, Showing Part of Goat Island

A wondrous church it was indeed,
By Nature's changeless laws decreed,
Tho' man reared not the structure fair,
All churchly attributes were there!

The gorge was the glorified nave,
Whose floor was the emerald wave,
The mighty fall was the reredos tall,
  The altar, the pure white foam,
The azure sky, so clear and high,
  Was simply the vaulted dome.

The column of spray
On its upward way,
  Was the smoke of incense burned,
And the cataract's roar,
Now less, now more,
As it rose and fell,
Like an organ's swell,
  Into sacred music turned.

While, like a baldachin o'erhead,
The spray cloud in its glory spread,
Its crest, by the setting sun illumed,
The form of a holy cross assumed."

Father de la Roche Daillon is the first white man known to have been on the Niagara River. He crossed it near the site of Lewiston, in 1626. But though we have no record of any prior visit of a white man, it is more than probable that such had been made.

POINTS OF HISTORIC INTEREST ALONG THE NIAGARA RIVER

On the American Side

Buffalo, at the source of the river, is the eighth city of the Union in point of population, which in 1900 was 355,000. It is famous as the western terminus of the Erie Canal, and also as the chief eastern port of lake navigation. It is situated twenty-two miles from the Falls. It was a village in 1813, when it was burned by the British, only one or two houses being left standing.

Black Rock, formerly a village, now a part of Buffalo, was famous in the War of 1812. Inside of the present limits of Buffalo, along the river shore, some seven or eight so-called forts or batteries were located; as was also a blockhouse, built about 1810, at the mouth of the creek. In Black Rock, General Smythe of Virginia collected 5,000 men, who responded to his bombastic circular asking all to retrieve the Nation's honor and share in the glory of an invasion of Canada. There was no invasion of Canada at that time, though there was much fighting, and two invasions at other periods during the war.

Grand Island is noted as the proposed site, in 1825, of Major M. M. Noah's "New Jerusalem," or the industrial centre for the Jews of the new world. Beyond the laying of the corner stone, with due ceremonies, on the altar of a Christian church, in Buffalo, the project never made any advancement.

Tonawanda, eleven miles above the Falls, is famous as a lumber market, holding the second place in America, being next to Chicago, in the amount of lumber handled.

The village of La Salle, five miles above the Falls, close to the mouth of Cayuga Creek, was named after the famous explorer La Salle, who at this very point, in 1679, built his vessel, the "Griffon," the first craft other than an Indian canoe, that floated on the upper lakes. Here, too, about 1800, the United States Government established a navy yard.

Burnt Ship Bay, at the lower end of Grand Island, derives its name from the fact that there the defeated French (who hastened from the West to aid in the defense of Fort Niagara, in 1759), in their flight, burnt and sunk two small vessels, in order to prevent their falling into the hands of the victorious British.

At Schlosser Dock, on the night of December 29, 1837, occurred the "Burning of the Caroline." She was an American boat and was thought to be rendering aid to the Patriots on Navy Island. Six boatloads of British soldiers crossed from Chippewa, seized her, towed her far out into the stream, set her on fire and let her drift over the Falls. The incident came very near to involving the United States and Great Britain in a war.

Below Schlosser Dock, and midway between it and the old stone chimney, was located Fort Schlosser, built by the English in 1761 and named after its builder. Just below this was located Fort de Portage, or Fort Little Niagara, built by the French about 1750. This was burned by Joncaire in 1759. Here stands an isolated stone chimney, the oldest remaining bit of perfect masonry on the frontier, if not in all Western New York. It was attached to the barracks which the French built for Fort Little Niagara, and was also attached to the mess house which the English built in connection with Fort Schlosser.

The road running back into the country is still called the Portage Road, and was the old road over which, from the middle of the last century, was carried all the vast freight going to and coming from the West. Less than half a mile up this road from the river are still to be plainly seen the earthwork outlines of a blockhouse built by Captain Montresor in 1764. This was one of eleven built by him that year to protect the portage between Fort Schlosser and the top of the mountain above Lewiston. The Niagara Falls Power Company's power houses are on the river bank a short distance below.

Below the next mill the river runs in close to the road, and the spot is still known as Frenchman's Landing. This was the upper end of the earliest portage from Lewiston to the upper river; was in use by the Indians probably before 1600 and from about 1700 in a small way, and from 1720 to 1750 was a much-used highway of commerce under French control. Here, in 1745, the French built a stone blockhouse and a storehouse, known as the first Fort Little Niagara.

Next come the Niagara Rapids and Falls, and the Reservations.

The small settlements at Schlosser and Manchester (now the City of Niagara Falls) were burnt by the British in 1813.

No point of immediate historic interest occurs until we reach the Devil's Hole, a spot famed as the site of the "Massacre" of the British by the Senecas, in 1763, one of the most noted historic incidents of the frontier.

The Tuscarora Reservation, containing some 6,000 acres, lies above the mountain, some three miles east. The Tuscaroras were the first settlers along this frontier, in 1780, and have always been the firm friends of the United States.

The bluff on top of the mountain, six miles from the Falls, is, geologists tell us, the old shore of Lake Ontario. On this bluff, in 1678, and at this point, stood Father Hennepin and La Salle, having climbed up the steep ascent from the plain below, which, from its three plateaus, Hennepin calls the "three mountains." Here, in 1764, was built the first of the eleven blockhouses above referred to. Here, also, was located the upper end of the first railroad ever built in America. It was built of logs laid on crude piers and ran, in a presumably straight line, from this spot on the cliff directly down the edge of the bluff to the water. True, it was of wood, but cars ran on it. It was operated partly by hand power, which the Indians supplied; for an Indian brave, who would scorn any other manual labor, was content in those days to work at the windlass for a whole day, receiving in payment about one pint of whiskey and a plug of tobacco, luxuries unobtainable in any other way.

Over this incline, which was built by Captain Montresor, and which continued in active operation for over thirty years, was carried the entire freight going westward; not only the boats, cannon and military stores for all the western English posts, but also the vast amount of freight of every description and the boats and goods of that large force of men who were known in history as fur traders.

At this point on top of the mountain, also, was located Fort Gray in the War of 1812.

The village at the foot of the mountain is Lewiston, named for Governor Morgan Lewis of New York, and was once a place of importance as the head of navigation on Lake Ontario. On its site is believed to have stood the important village Onguiaahra of the Neuters.

At the foot of the bluff above the village ended the incline railway already spoken of, and close to it were the rude wharves to which came the light-draft, old-fashioned and clumsy vessels of various descriptions that brought, mainly from Oswego, all the stores, both military and commercial, destined for the far West.

On the first plateau above the river overlooking these wharves stood the storehouses in daily use for all this

The Inclined Railway at Lewiston

merchandise during the last half of the eighteenth century, and here was located, for their defense, the English fort from which the two ill-fated companies started for the Devil's Hole. Near here, too, in 1678, Father Hennepin landed, built a little cabin of palisades, and said one of the early masses celebrated on the river. It may not have been the first, for we know that Father Daillon was on this river in 1626, and to him possibly belongs the honor of being the first celebrant on this frontier.

Here, in 1719, was built the first trading house on the Niagara. Erected under peculiar circumstances, it was destined to be a point of vast historic importance. From 1688, when England compelled the destruction of Fort De

Nonville, which stood where Fort Niagara now stands, both she, the victor, and France, the vanquished, desired the reërection of a fort at this location. Chabert Joncaire, a Frenchman by birth, a Seneca by adoption, and a power among the Indian tribes, and whom Charlevoix describes as "speaking with all the good sense of a Frenchman and with all of the eloquence of an Iroquois," was so beloved by the Senecas that they wanted him to make his dwelling place amongst them, offering him the location of a site wherever he chose, and to locate one of their villages around him.

Pursuant to French instructions, he located his cabin on the river bank at Lewiston. It was called "Magazine Royal," and was ostensibly a trading house, but in reality it was a fort. Over it floated the flag bearing the lilies of France. Its attendants were all French soldiers, and ere a year had passed it was described as a heavily-built log house, forty feet long by thirty feet wide, two stories high, musket proof, with many portholes in its upper story, and surrounded with palisades. It was possible to locate the fort on this plea at this point, because Lewiston was the head of navigation on the river, and Fort Niagara, where the fort was really desired, was seven miles away, and a fort could not be built there with the same pretense. Joncaire's house stood for about six years, and then the French obtained the consent of the Senecas to build a dwelling where Fort Niagara now stands.

Two miles below Lewiston are the five-mile meadows, where, in December, 1813, the British crossed the river for their night attack on Fort Niagara.

Fort Niagara, one of the most historic spots in North America, stands to-day practically defenseless, but bearing within its walls the relics of almost two and a half centuries. On this point of land, in 1669, La Salle built the first structure, other than an Indian wigwam, ever erected on this frontier. On this site, in 1678, La Salle built Fort Conti. On its ruins, in 1687, De Nonville built the ill-fated fort that bore his name, which was besieged by the Senecas as soon as the army departed, and was destroyed the following year, on the demand of the Senecas, acting under British instigation.

In 1725, the French erected, by consent of the Senecas, a stone structure on the present site of the Castle, whose foundations are to-day no doubt the oldest existing masonry west of Albany. This fort was gradually strengthened and enlarged by the French until, at the time of its attack by the British in 1759, it was as strongly fortified and protected as the science of that day, with such material as could be gathered at so far off a point, could possibly make it. The description of that siege, including the three parallels built by the British along the lake shore, the death of General Prideaux, and the subsequent defeat of the French relieving force from the West by Sir William Johnson, thus acquiring for England that spot which for over half a century she had desired and where for at least a score of years previously her hated rival, France, had maintained a centre of military and commercial activity, are matters of history; but of the buildings that stand in Fort Niagara to-day, the lower part of the stone walls dates back to 1832, and the upper part of these walls to about 1861. The earthworks were constructed at least one hundred and fifty years ago, while their brick facings date only from about 1861. The large building, the Castle, or mess house, dates from 1725. The first and second stories of stone date back prior to 1759, while the timbered roof dates from just prior to the American Revolution. It was the strategical centre of the middle part of North America for over one hundred years, and during the eighteenth century its commandant, whether English or French, was the most important man west of New York. The two stone blockhouses, the best specimens of their kind extant in America, were built in 1770 and 1771 by the British. The old bakehouse, built in 1762, replaced an earlier structure. The hot-shot furnace, first built prior to 1812, was rebuilt some fifty years ago.

The long, low stone barracks were constructed by the French about 1750, and about that same time they built the square magazine which stands to the right of the entrance gate. The roof of this magazine is a huge, thick stone arch, the modern shingle roof having been erected over that.

Between the fort and the village of Youngstown, along the river shore, a line of batteries extended during the War of 1812.

"Niagara is without exception the most important post in America and secures a greater number of communications, through a more extensive country, than perhaps any other pass in the world." So wrote Major Wynne in 1770 His opinion was probably correct, for no one spot of land in North America has played a more important part in the control, growth and settlement of the Great West than the few acres embraced within its fortifications. Its cemetery is the oldest consecrated ground west of Albany.

On the Canadian Side

At the source of Niagara River stand the ruins, part of stone, part of earthwork, of Fort Erie, famed in the War of 1812. The first fort near this site was built in 1764, as a depot of supplies for General Bradstreet's army. The waves of the lake undermined and battered the foundations, so that, about 1781, a new location, nearer the source of the river and on the bluff out of the reach of the waves was selected, and a second fort was built. In 1807 this was abandoned and part of the earthworks on their present location were constructed. It was enlarged by the British, in 1812, by the addition of the stone buildings which face the river; and still further enlarged, in 1814, by the Americans, when in possession of the fort for the second time during that war, by the addition of two large bastions and connecting works in the rear and on the side. In 1814, the Americans, after the battle of Lundy's Lane, established themselves in this fort, and here soon afterwards they were besieged by General Drummond.

A little way down the river, and extending inland, the British established a line of siege works and two batteries, and in the northwest bastion, during one of the

British attacks on the fort, occurred one of the most tremendous losses of life, due partly to hand-to-hand conflict and partly to the explosion of the magazine, that has ever occurred in any war in so small a space.

From Fort Erie, on September 17, 1814, the Americans made that famous sortie planned and led by General Peter B. Porter, which, in the words of Sir William Napier, "is the only instance in history of a besieging army being utterly routed in a single sortie," and which event ended the "War of 1812."

No other site of historical importance exists on the river bank until we reach Navy Island. Though back of Fort Erie some five miles, Navy Island is the scene of the Battle of Ridgeway, fought between the Canadians and the Fenians in 1866.

The Island contains 340 acres and belongs to Canada. It is the only island of any size that fell to her lot in determining the boundary line between the United States and Canada, which line runs through the deepest channel of the river. Navy Island is famed mainly as the headquarters of the Patriots during the War of 1837.

On the main shore, just east of the village of Chippewa, are the fields where, on July 5, 1814, was fought the Battle of Chippewa. On both sides of the mouth of Chippewa Creek were located batteries during the War of 1812. On the western bank of this creek, from 1794 until after 1800, stood one of the ordinary pattern of blockhouses, built for the protection of the portage around the Falls on the Canada side, and dignified by the name of Fort Chippewa.

One mile west of the Falls, on the highest point of land, on July 25, 1814, was fought the famous battle of Lundy's Lane. Commenced late in the afternoon, this battle, largely a hand-to-hand conflict, was continued beneath the glorious light of a summer moon until long after midnight; while the ceaseless roar of Niagara thundered the dirge of the many that fell on both sides. The central point of the battlefield was a battery located on the hill where the village cemetery and a monument in honor of the British who fell in that battle now stand.

The Canadian Falls, Viewed from Goat Island

This hill was captured by the Americans and held against repeated assaults, only, after the bloody victory had been gained by the Americans, to have General Brown, their commander, order the army back toward Chippewa, leaving the cannon, for whose capture so many lives had been lost, unspiked and alone on the hill, which early the next morning the British, without opposition, reoccupied. It is one of the most famous battles in history—remarkable in that even now, nearly a hundred years afterwards, the Americans still claim the victory, and the Canadians, going still further, annually celebrate on the battlefield, with pomp and ceremony, a famous victory which in the opinion of their American cousins they did not win.

The village of Drummondville, one-half mile west of the Falls, was named in honor of General Drummond of the War of 1812.

Queenston Heights, where was fought the battle of October 12, 1812, is marked by the noble monument to General Brock. The remains of the earthworks of Fort Drummond are easily traceable.

A cenotaph at the foot of the heights marks the spot where General Brock fell, mortally wounded.

Queenston, a small village below the heights, was so called in honor of Queen Charlotte.

The village of Niagara, near the mouth of the river, called also, at various times, Newark and Butlersbury, is older than any settlement on the eastern bank. In 1792 it became the residence of the Lieutenant-Governor of Canada, and here was held the first session of the Parliament of Upper Canada.

Fort George, whose vast earthworks are plainly discernible to-day, was commenced in 1796 to provide a habitation for the British garrison, which, soon after in that year, evacuated Fort Niagara under Jay's Treaty.

It was enlarged prior to the war of 1812, and doubled in size, in the immediate preparation for that war, and was, of course, the military centre of the Canadian lower Niagara during that period. From here General Brock, who was in command, started to take part in the Battle of Queenston Heights, and when he returned it was in his coffin, to be buried in the Cavalier Bastion of the fort, from whence his remains were subsequently removed to their present tomb in Brock's monument. Here, in 1813, the Americans, attacking from the lake side, captured the village and the fort, which they held until December of that year, when General McClure, the American general, on a day's notice, without provocation, set fire to and burned the village, thus turning the inhabitants out into the cold. His destruction of the buildings in the fort and of the tents and other military stores (which he left unharmed) would have done far more good for the American cause and have left far less benefits for the advancing British than they found when they entered the fort. This act so aroused the British soldiery that it resulted in the retaliation and the utterly unnecessary attack and massacre at Fort Niagara and the burning of the Niagara frontier.

Fort Mississaga, a stone blockhouse, surrounded by high earthworks, stands to-day a perfect specimen of the early nineteenth century fort. It was built by the British in 1814, when they held control of Fort Niagara; for without their occupation of that fort, being directly covered by the guns thereof, it could not have been built. Neither during the War of 1812 nor during any subsequent period has it played any important part. During the War of 1812 the water front for a mile up from the mouth of the river was a line of batteries.

Navy Hall, the residence of Governor Simcoe, the first Governor-General of Upper Canada, is still standing, a long, low, one-story wooden building (where, in 1792, met the first Parliament of Upper Canada), though not on its original site.

About a mile back from the river are still seen the wooden barracks occupied during the Revolution by that noted band of white, but savage, warriors known as "Butler's Rangers."

GEOLOGIC NIAGARA

During the last seventy-five years geologists have written a great deal about Niagara, and from it speculatists have deduced theories as to the antiquity of the earth, trying to prove

> "That He who made it, and revealed its date
> To Moses, was mistaken in its age."

In early geological days this entire section was covered by the salt waters of the Silurian seas, which is proved by the shells of the Conularia Niagarensis, found in the shale underlying Goat Island and along the gorge; this shale having once been the muddy bottom of these seas, and this shell being found only in salt water.

At a later geological period, on top of what is now this shale, at the bottom of a warm ocean, still covering all this land, grew a vast, thick and solid bed of coral, of which ancient life the Niagara limestone of to-day is a monument.

Subsequently, these two ancient and contiguous sea bottoms, then solid stone, were uplifted, and by the configuration of the earth hereabouts the original Niagara River was formed. In general terms its course was similar to that of the present river (though its volume was not as great) as far north as the Whirlpool, from whence it ran, in a broadening channel, to St. David's, westerly from its present outlet; and prior to the coming of the ice age it had cut this channel back to the Whirlpool and perhaps even farther south.

Next came the glacial period, when this part of the country was enveloped with a covering of ice (working down from the northeast) similar to that now covering Greenland, though having a depth of hundreds of feet. This ice age, as approximately determined, lasted 50,000 years, and closed about 200,000 years ago.

This ice sheet, as it moved forward and southward, broke off all the projecting points of rock and scraped all the rocks themselves bare. Its presence and power are attested by the scratchings and markings on the smoothed surfaces of the top layer of rock wherever it is laid bare, as far south as the Ohio River, and is apparent on Goat Island and along the frontier. This ice sheet brought down in its course not only boulders from the far north and northeast, but its own vast accumulations and scrapings and abrasions which we call "drift," and with this drift it filled up (and with its enormous weight pressed compactly) all valleys, gorges and indentations of the earth in its course, among them the old outlet or bed of the Niagara River from St. David's to the Whirlpool.

Many of the boulders brought here in the ice age, carried perhaps hundreds of miles, have been collected in this section and used in the construction of the bridges that have been built on the Reservation, on the main shore, opposite Goat Island.

On the recession of the ice sheet a second Niagara River came into existence.

The weight of this vast ice sheet had canted or tilted the land to the northeast, so that at its recession the waters of the present three great northern lakes flowed east by the Ottawa and later, as the land rose, by the Trent Valley. As this second Niagara River drained only the Lake Erie basin, and as Lake Erie was very much smaller than at present, it worked in a small channel, was of small volume, and had but small rock-cutting power to take up the erosive process of the earlier Niagara River, which had drained only this same Lake Erie basin.

This is the period, again referred to, when the present channel to the south and west of Goat Island (the Canadian channel) was made.

The second Niagara River gradually merged itself into a vast fresh-water lake, formed by the melting ice and heavy rainfalls, and covering all the Lake Erie basin, and gradually rose in level until it stood fully 100 feet above the present rocky bed of Goat Island.

Its northern boundary was the escarpment or ridge whose lowest point was just above the present village of Lewiston, which point is thirty-two feet above the present level of Lake Erie. *Here the rising waters first broke over the dam, and here Niagara Falls were born.*

From here they cut their way back to the Whirlpool, for the waters found it easier to cut a new channel back through the soft rock from this point in the embankment than to scour out the old drift-filled channel (which was at the very bottom of the lake) from the Whirlpool to St. David's.

The flow of the lake set towards the Falls and brought down from the Erie basin fluvial deposits in large

The Suspension Bridge Across Niagara River at Lewiston

amounts during the succeeding years, depositing them all along the bottom of the lake. It is of these fluvial deposits, consisting of sand and loam (excepting a comparatively small layer of drift next to the top rock), that the soil of Goat Island is formed, and of which the soil covering the rocky substrata along the gorge is formed.

This Goat Island soil, more than any surface in this section, is the geologists' paradise. While some lands and forests near here may not have been cultivated by man, the western end of Goat Island is an absolutely unique piece of virgin forest.

Most of the time it has been, in general terms, inaccessible to man; and since accessible by bridges, no cutting of the trees, no clearing of the land nor cultivation thereof, no pasturing of cattle, in fact, no disturbance of the soil has been permitted.

Here, then, is the original drift, with the subsequent overlying alluvial deposits and accumulations, undisturbed by man. And when, as in this case, in this undisturbed fluvial deposit are found fresh-water shells, it proves that the Niagara River to-day flows through what was once the bottom of a vast fresh-water lake that covered all this section.

As the Falls cut their way backward, so their height gradually diminished, and the level of this fresh-water lake fell until, finally, there came a time when the land of what is now Goat Island rose above the waters. That this lake existed at a comparatively recent geological period is proven by the fact that these shells now found on Goat Island are identical in species with those found inhabiting the Niagara River and Lake Ontario to-day. According to the most accurate calculation, the consensus of geological opinion is that 35,000 years have elapsed since the Falls were at Lewiston, which is seven miles away; and that the fluvial deposits on the island began as soon as the river rose over the moraine at the foot of Lake Erie can scarcely be doubted.

That in 35,000 years there is no specific difference between the ancient shells found in the soil of Goat Island and their existing representatives and progeny in this locality is wonderful indeed.

When the Falls in their recession shall have reached the head of the rapids they will be about fifty feet higher than they are now, or over 200 feet in height, less whatever the upward slope of the bed of the river below the Fall may diminish that total, and it cannot be by many feet. The average dip of the rocky strata to the south is twenty-five feet to the mile, and the average slope of the river channel in the opposite direction is fifteen feet to the mile.

When the Falls shall have receded yet another half mile, or a total distance of one mile from their present location, by the wearing away of the strata which dips rapidly downward, and by the continued, but gradual elevation of the bed of the river, and therefore of the surface of the water below them, they will have decreased in height to about 100 feet. And when they shall have receded still another mile, their height will be only about sixty feet.

As geologists differ by thousands of years as to how long it took the Falls to cut their way from Lewiston ridge to their present location it would be impossible to say when in the history of this section the waters had so far drained off that the muddy deposits overlying the rocky bed of what is now Goat Island first appeared above the slowly-receding waters of the lake, unless we adopt some length of time for this work as a basis.

But it is not so difficult, by noting the elevation of the land, the trend of the rocks and the depth of the overlying "drift," to locate approximately where the Falls were when this occurred. At that time, judging from the present levels of the land, the Falls must have been at a point nearly a mile north of the present location of the Horseshoe Fall. And if we accept, as above, one foot a year as a fair average estimate of the recession of Niagara from Lewiston Heights in the more recent geological time, it must have been between four and five thousand years ago that the soil of Goat Island, then a part of the mainland, first appeared; and probably it is nearly as long since it became an island.

In speaking of the recession of Niagara, the recession of the Horseshoe Fall is referred to, for it recedes several hundred times as fast as the American Fall; for in the time that the Horseshoe Fall has receded from Prospect Point, at the lower or northern edge of the American Fall, across the width of the American Fall and across the width of Goat Island to its present position, the American Fall has receded but a very few feet. Hence, on these deductions, Goat Island has existed as an island from about the time of the Flood, or from about 2,300 B. C.

This proves the statement that "in a scientific sense the island is of trifling antiquity, in fact, it would be difficult to point out in the western world any considerable tract of land more recent in its origin."

Niagara has been called the "sun clock of the ages," and the stratification of the rocks through which it has cut its way may be studied at many points, especially at the "Whirlpool Rapids," above the Whirlpool, where both shores of the gorge are little covered with foliage, and again on the Goat Island cliff.

The Whirpool Rapids

PART II

AMERICAN NIAGARA POWER DEVELOPMENT BY CANAL

General View of the Power Development by the N. F. H. P. & Mfg. o., Showing the Earliest and the Latest Methods of Utilizing Water from its anal

The Niagara Falls Hydraulic Power and Manufacturing Company

IN the development of the Niagara Falls Hydraulic Power and Manufacturing Company there is to be found the oldest power project at Niagara Falls. In the year 1852 the Porter family, which was among the early settlers and much interested in the future of the place, donated the land necessary for the construction of a canal extending from the upper river to the edge of the high bank a short distance below the falls. In the year mentioned, negotiations were commenced with Caleb J. Woodhull and Walter Bryant for the construction of the power canal. Under the agreement made, these men were to construct the canal and receive a plot of land having 800 feet frontage on the upper river, and a strip 100 feet wide extending the entire length of the canal, namely 4,400 feet. They also received 75 acres of land about the lower end of the canal, which plot had a frontage of nearly a mile along the high bank.

The Niagara Falls Hydraulic Company was incorporated in March, 1853, with Caleb J. Woodhull as president, and Walter Bryant, agent. This company immediately contracted for the construction of a canal 70 feet wide and 10 feet deep, with wharves along the company's land on the upper river. The turning of the first sod was made the occasion of a celebration. Work progressed for 16 months, when a lack of funds caused suspension of operations. In 1858 the work was resumed by the Niagara Falls Water Power Company, of which Stephen M. Allen was president. On Saturday, September 1, 1860, Horace H. Day secured control of the property, and by July 1, 1861, had completed a canal 36 feet wide and about eight feet deep. The breaking out of the Civil War delayed operations, and for years the canal stream poured over the cliff unused. Early in the '70's, Charles B. Gaskill built a grist mill at the lower end of the canal, and thus became the first user of the canal power.

In the year 1877 the canal property and all its belongings and rights were purchased by the late

Upper End of Canal
The Niagara Falls Hydraulic Power and Manufacturing Company

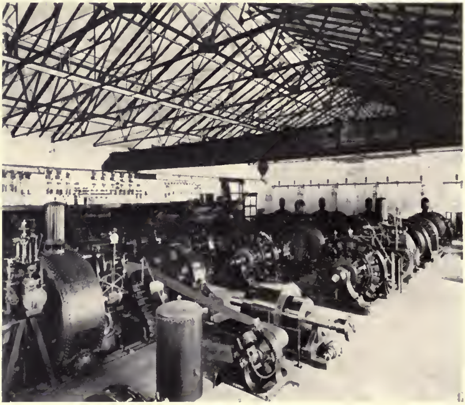
Jacob F. Schoellkopf, father of Mr. Arthur Schoellkopf, and the late Abram Chesbrough. These men organized the present Niagara Falls Hydraulic Power and Manufacturing Company, of which Jacob F. Schoellkopf was president up to September 15, 1899, the day of his death. From the date of the acquirement of the canal property by this company, the development has continued steadily, and what the company has accomplished has been a large factor in the development of the industries of Niagara Falls. They proceeded along the conservative lines that characterize all the Niagara development. To-day the canal has a width of 100 feet for its full length, while its final depth will be 14 feet. At the lower end of the canal proper there is a basin 850 feet long and 70 feet wide, the length of which is to be still further increased to 1,000 feet. Extending from this basin to forebays located close to the edge of the high bank are two connecting canals, through which water flows from the basin to the forebays and then through penstocks to the turbines.

It should be remembered that the early development of the Niagara Falls Hydraulic Power and Manufacturing Company was begun before engineers and manufacturers dared to design and build water-wheels for use under the high head possible in connection with this plant. For this reason, shafts or pits were sunk in the rock near the edge of the cliff to such depths as were considered safe for the operation of the water-wheels then made. These depths varied from 25 to 75 feet. The turbines were located at the bottoms of these pits, from which the water escaped through tunnels into the gorge below. The discharge from some of these tunnels is still to be seen at Niagara, as portrayed in an accompanying illustration. Vertical shafts were installed to bring the power to the surface of the ground.

In 1881 the Niagara Falls Hydraulic Power and Manufacturing Company established its first station to supply electricity for commercial purposes. This station was known as Station No. 1, and was located in what was then Quigley's mill, now the Cliff Paper Company's mill. In this station were installed arc light machines to furnish a street and store service, the machines being operated from the mill shaft. It was here that the public distribution of electricity in Niagara Falls began.

In 1895-96 methods applied to the development of power had made considerable progress, and about this time the Niagara Falls Hydraulic Power and

Manufacturing Company began the erection of Power House No. 2. This power house was erected at the water's edge in the gorge, and was so designed that the water could be used under the full available head of 210 feet. Not only was this made possible, but the company was also able to take advantage of the use of horizontal shafts for turbines and generators which method practically eliminates all bearing



Interior of Station No. 2
The Niagara Falls Power and Manufacturing Company

trouble, not a single shut down from any such trouble having been necessary in seven years.

In the first section of this power house there were installed four double discharge Leffel turbines giving a total capacity of 6,850 horse power. A steel penstock eight feet six inches in diameter carries the water supply for these wheels from the forebay at the top of the cliff to the power station below.

The first section of the gorge power house having proved a great success, the company at once added two more sections making a station 170 feet long by 100 feet wide. The construction is of stone and steel. In this power house there are now in operation 15 turbines, the capacity of 14 of them ranging from 1,600 to 3,500 horse power. The combined output capacity is about 34,000 horse power. The turbines of the two sections last built receive their supply of water through steel penstocks 11 feet in diameter. In respect of their power capacity, these penstocks are the largest in the world.

In this connection it is interesting to review the machines driven by each turbine, and the application that is made of the electric power so developed:

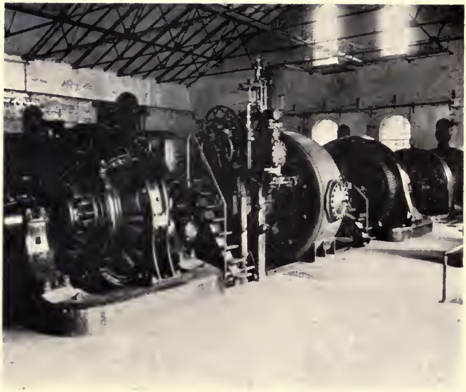
Turbines Nos. 4, 5 and 6, each drive two 560-kw. 300-volt, direct current, Westinghouse generators, the current from which is supplied to the Pittsburg Reduction Company.

Turbine No. 7 drives two 560-kw., 550-volt, direct current generators of General Electric make. One of these generators carries a commercial load, supplying current to the Niagara Falls Brewing Company and to fifty other users of power. The other generator carries a railway load, for the operation of the Niagara Gorge Railroad. A booster with a range of 300 amperes is attached, and is in circuit with the Youngstown and Lewiston railroad fourteen miles distant from the power house. Turbine No. 7 has also conected to it one 200-kw., 135-volt generator, the current from which goes to the National Electrolytic Company. Both generators and booster are of General Electric make.

Turbine No. 8 has attached one 875-kw., direct current generator, feeding 5,000 amperes, 175 volts, to the National Electrolytic Company. The generator is of General Electric make, and is of the double commutator form. It is shown in one of the accompanying illustrations. Turbine No. 8 also drives an alternating current generator of 1,000-kw., 11,000-volts, 3-phase, and of Bullock make.

Turbine No. 9 has attached a General Electric generator of 875-kw., 5,000 amperes, 175 volts, current from which goes to the National Electrolytic Company, and also a 1,000-kw., direct current, General Electric, 325-volt, 3,100 ampere generator, the current from which goes to the Acker Process Company.

Turbine No. 10 drives two General Electric, 1,000-kw., 325-volt, 3,100 ampere generators, the current from which is used by the Acker Process Company.



No. 8 Turbine Driving 875-Kw. 5000 Ampere Generator
The Niagara Falls Hydraulic Power and Manufacturing Company

Turbine No. 11 and turbine No. 12 each operate two Westinghouse, 750-kw., direct current, 300-volt, 2,500 ampere generators for the Pittsburg Reduction Company.

Turbine No. 13 has a Bullock 1,000-kw., 11,000-volt, 3-phase generator on one end, and on the other end a 700-kw., 2,200-volt, single-phase alternator, made by the Walker Manufacturing Company. This latter machine supplies the current for over fifty per cent. of the incandescent lighting throughout the city. It is operated for the Buffalo and Niagara Falls Electric Light and Power Company.

Turbine No. 14 and turbine No. 15 each operate two Westinghouse, 1,000-kw., 300-volt, 3,330 ampere generators for the Pittsburg Reduction Company.

Turbine No. 16 and turbine No. 17 each operate two Westinghouse, 750-kw., direct current generators for the Pittsburg Reduction Company.

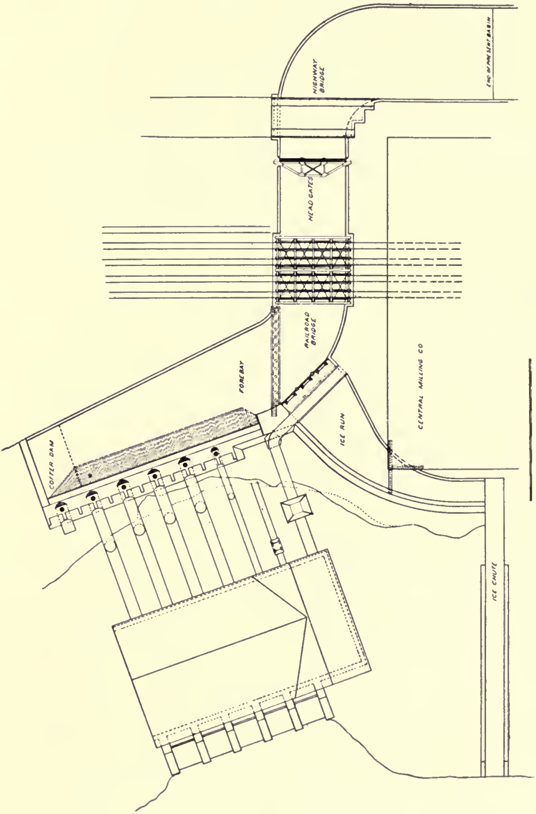
Turbine No. 18 is a 250-h.p. wheel made by J. M. Voith, Heidenheim, Germany. It drives the exciters used in connection with the 3-phase alternators above referred to.

Turbine No. 19 is of 500 h.p., and drives a 400-kw., 500-volt generator, for commercial service.

In addition to the distribution of electric power as above outlined, the Niagara Falls Hydraulic Power and Manufacturing Company has tenants to whom it supplies hydraulic power, as follows: The Cliff Paper Company, 2,500 h.p.; Cataract City Milling Company, 700 h.p.; Pettebone-Cataract Paper Company, 2,200 h.p.; Oneida Community Company, Ltd., 300 h.p.; City Water Works, 400 h.p.; Niagara Falls Milling Company, 1,800 h.p., making a total of 7,900 h.p.

Inasmuch as it was possible to locate factories very close to the power house, practically the entire electrical development has been in the forms required by the different industries. The majority of these call for direct current at voltages varying from 175 to 300. However, the last two machines to be installed in this power house were 1,000-kw., 11,000-volt, 3-phase alternators, built by the Bullock Manufacturing Company. An illustration given herewith shows one of the horizontal shaft turbines, to one end of which is connected an 875-kw., direct-curent generator, while at the other end is connected one of the 1,000-kw. alternators. These alternators are the first installation of alternating current machinery made by the company.

The 11,000-volt current generated by the machines

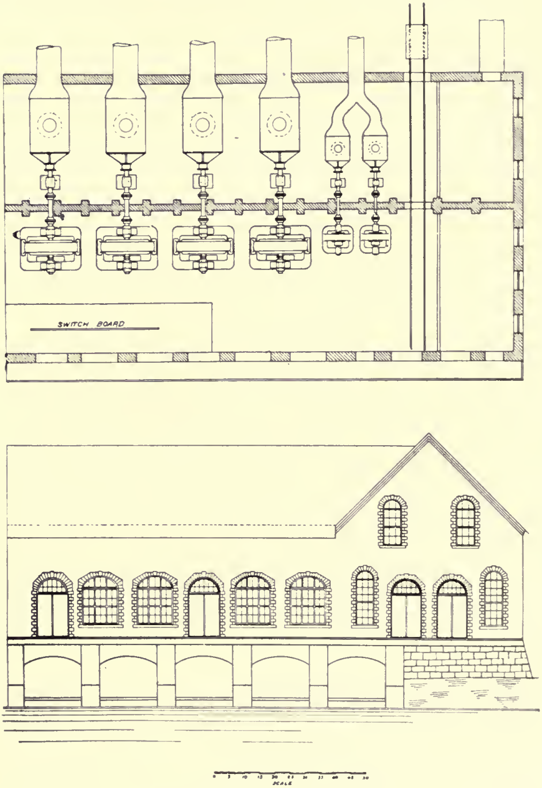


General Plan of Station No. 3
The Niagara Falls Hydraulic ower and Manufacturing Company

attached to turbines Nos. 8 and 13 is transmitted by a 3-phase, lead-covered cable system to a transformer station located on the top of the cliff along the canal basin. In this station the voltage of a portion of the current is reduced to 2,200 for transmission and use in the vicinity, the building also serving as the terminal station of an overhead transmission line carrying power at high voltage to the company's factory property at the north end of the city. This property is connected with the railroad lines by a switch over a mile long laid by the company. On this land the new plant of the Carter-Crume Company, and the plant of the Central Machine Company are located.

The switchboard of Power House No. 2 is about 100 feet long and is located on a gallery that runs along the cliff side of the station. It has 32 panels of Vermont marble, on which are installed some of the largest switches in existence. The switchboard and station wiring are of fireproof construction, and the board is so arranged that although there are many different kinds of currents generated in the station, a relay is obtained for every generator and water wheel in the station, except the single-phase alternator. The 11,000-volt portion of the switchboard was designed and built by employees of the company.

The present development does not represent the full capacity of the Niagara Falls Hydraulic Power and Manufacturing Company's canal, and the company has commenced the erection of an additional power house. This new station will be located at the water's edge, in the gorge, north of the present station. When completed, it will have a length of 350 feet, and a width of 90 feet. Sketches of Station No. 3 are presented herewith. Unlike the present station, it will have a centre wall extending the entire length of the station, dividing the water wheels from the generators. The capacity of the station will be 100,000 horse-power, and there will be a



Power House No. 3
The Niagara Falls Hydraulic Power and Manufacturing Company

separate penstock to supply water to each 8,000 horse-power unit. These units will also be of the horizontal shaft form, and will run at 300 rev. per min., giving 25-cycle, 3-phase current, at 11,000 volts direct from the generators. It is expected that the first section of this power house will be in operation by January, 1906.

Tenants of The Niagara Falls Hydraulic Power and Manufacturing Company

THE NIAGARA FALLS BREWING COMPANY

THE Niagara Falls Brewing Company manufactures lager beer, ale, and porter. Its plant is operated by electrical power exclusively. The brewery has been in operation since 1880. It has an annual capacity of 90,000 barrels, with a storage capacity of 60,000 barrels. Its extensive cellars are excavated in the solid rock, the stone taken out having been utilized in the construction of the buildings. These buildings cover an area of two acres and are situated on the highest ground in Niagara Falls, on the river bank, commanding a beautiful view of the cataract above and of the Whirlpool Rapids below.

The cellars of the Niagara Falls Brewing Company are chilled by the direct expansion refrigerating system. The 60-ton refrigerating plant is of the vertical double-acting type, and is driven by a 500-volt direct current motor. This machine is capable of maintaining a temperature as low as 30° fahr. throughout the cellars, which have a capacity of 443,197 cubic feet. A second 500-volt motor serves to operate all the machinery in the brewery, including the mash machine, malt mill, freight elevator, keg washers, beer pump, rotary water pump, bottling works machines, etc. The power is obtained from the circuits of the Hydraulic Power and Manufacturing Company.

PETTEBONE-CATARACT PAPER COMPANY

THE predecessor companies going to make up the Pettebone-Cataract Paper Company rank among the oldest of industrial concerns at Niagara Falls, and were the pioneers in the manufacture of news paper in this locality. The first mill was located on Bath Island, now Green Island. News paper was first made from rags, later on from straw, and finally from wood.

This company was formed October first, 1892, by the consolidation of The Pettebone Paper Company and the Cataract Manufacturing Company. The latter company had erected on the Hydraulic Canal, in 1880, a mill for the manufacture of ground wood, used in the manufacture of news paper, and the former company had built a paper mill in the same locality in 1884.

The property of the company consists of a strip of land on the Hydraulic Canal with a frontage of 115 feet, extending back some 330 feet to the high bank of the river, on which are located a four-story brick mill 100 by 115 feet, containing two Fourdrinier paper machines, and all the machinery and apparatus required in a well-equipped plant. In the rear there is a three-story stone building for the manufacture of ground wood pulp.

Hydraulic power is used exclusively, the company developing 1,400 h. p. by the use of turbines placed one hundred feet down the high bank. Water is taken from the canal of the Niagara Falls Hydraulic Power and Manufacturing Company, and after passing the water-wheels is discharged into the lower river.

The daily output of the plant is twenty-five tons of finished news paper and twenty tons of ground wood pulp.

CLIFF PAPER COMPANY

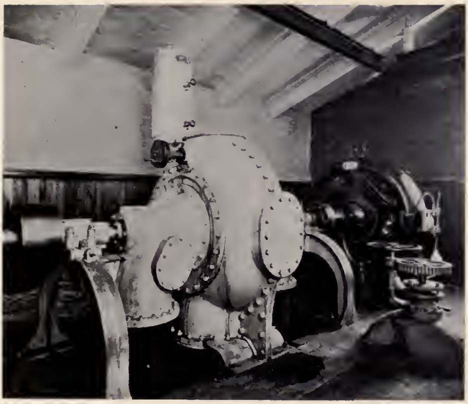
Paper Mill at Top of Cliff
Pulp Mill at Water's Edge
Cliff Paper Company

THE Cliff Paper Company is engaged in the manufacture of wood pulp and news paper. The process is common to all mills in the United States making this class of paper. The peculiar features of the plant are that the pulp mill, situated at the foot of the high bank, in the gorge of the Niagara River, is driven by water power, using water which has been used once under 75 feet head. After doing duty under this head, the tail water is delivered to a penstock running down 125 feet further and is utilized in horizontal turbine Leffel wheels giving about 2,500 h. p. These wheels are direct connected. The power is therefore used as economically as possible. The pulp is brought to the paper mill above the bank by a chain carrier.

The paper machines are driven by electric motors supplied with current from generators direct connected to 300 h. p. Leffel horizontal turbine wheels using tail water from other wheels.

The pulp mill and paper mill are connected by an inclined railway used for carrying freight and passengers.

The Cliff mill was the first development of Niagara water power under a head of over 100 feet, and was in operation before either of the power companies.



Turbine and Generator
Cliff Paper Company

WM. A. ROGERS, LIMITED

THIS business was started at Niagara Falls in 1893 under the name of the Niagara Silver Company. It has grown very rapidly and in 1902 it was amalgamated with the important business of Wm. A. Rogers, of New York city, at which time the present name of Wm. A. Rogers, Limited, was adopted. Several extensions of the manufacturing plants have been

Factory of William A. Rogers, Limited

made in recent years, and at the present time, in addition to the large plant now operated at Niagara Falls, the company owns and operates factories at Oneida, N. Y., and Northampton, Mass. The recent enlargement of the Niagara Falls factory has very considerably added to its capacity and at the present time the company is employing in Niagara Falls nearly 500 employees. The company manufactures silver plated ware and cutlery.

Gorge Below the Whirlpool
Niagara Gorge Railroad

THE NIAGARA GORGE RAILROAD CO.

The Niagara Gorge

IN its passage from the Falls to Lake Ontario the Niagara River passes through a deep and narrow cleft between rocky cliffs, falling, in its course of fourteen miles, more than 111 feet, and forcing its way through a channel so confined and precipitous that the tumult of the waters makes a scene of grandeur that, in the estimation of many travelers, exceeds the spectacle of the cataract itself. The only means of entrance to the Gorge is by the Niagara Gorge Railroad, a well-built, double-track electric road, whose cars start from Prospect Park, Niagara Falls, and traverse the length of the Gorge to Lewiston in forty-five minutes, running the entire distance within a few feet of the water, and giving the passenger an opportunity to obtain an unrivaled view of the Rapids and Whirlpool, or to stop at various points for a longer inspection of the wonders of the mighty river. The construction of the Gorge Road is considered by experts to be one of the greatest engineering feats of modern times. For years engineers contended that it could not be built, but in 1890 surveys were made by Mr. George A. Ricker, a civil engineer of Buffalo, N. Y., which proved that it was perfectly feasible to construct a railroad through the Gorge that would be at once safe and comparatively easy of operation. Work was begun soon afterwards, and in 1895 the road was opened for passenger traffic. The completion of the road—which was rebuilt and improved in 1890—makes it possible for the tourist to visit the Gorge from end to end where before it was only accessible in spots.

Entrance to the Gorge

Passing down a moderate incline, the Gorge Road takes the sightseer under the two railroad bridges which, spanning the Gorge below the Falls, give access to Canada, as well as providing the most direct rout between the East and the great West. The cantilever bridge of the Michigan Central Railroad was built in 1882; while the steel arch bridge, built in 1897 by the Grand Trunk Railroad of Canada, replaces the familiar old Suspension Bridge, which was long one of the wonders of this point. The Grand Trunk bridge is said to be the largest arch in the world.

The Whirlpool Rapids

Just below the railroad bridges the gorge suddenly narrows and the Whirlpool Rapids begin.

Between the Falls and Whirlpool Rapids
Niagara Gorge Railroad

The depth of the channel of the river at this point has never been ascertained. So precipitous is the rocky bed of the stream that the river reaches a speed of twenty-seven miles an hour, and the waves which are formed in its passage reach a height of thirty feet at times. Two attempts have been made to navigate these rapids in vessels, both being successful. The original "Maid of the Mist" was taken through the lower river safely several years ago, and C. A. Perry of Niagara Falls went through safely in a lifeboat, which he made himself. Two persons have attempted to swim through the rapids. One got through alive, but the other, Capt. Matthew Webb, an Englishman, who had swum the English Channel sucessfully, lost his life in the Niagara rapids, on July 24, 1883. Several persons have gone through the rapids successfully, inclosed in barrels built for the purpose.

The Niagara Whirlpool

Three quarters of a mile below the bridges the river broadens, and, changing its course suddenly, an immense whirlpool is formed, into which is gathered all the floating material that the current has brought down from above. Driftwood, which may have started on its course to the sea far up in Lake Superior, may be seen whirling slowly about in the surface current that seems to make a complete circle from side to side of the chasm. Occasionally, the fragments of a wrecked vessel will be seen in the Whirlpool's clutches, brought from above the Falls by the river, and here, too, are usually found the bodies of the unfortunates who, through accident or the deliberate intent to end their lives, are carried over the cataract to a certain death. Many accidental deaths occur every year in this way, while Niagara Falls has long been known as a favorite resort for suicides. Once the unfortunate victim is in the grasp of the swift current above the Falls there is no hope for him, although the history of the region teems with stories of efforts to succor those whose rashness or folly has led them too near the brink of the Falls.

The passenger on the Gorge Road who looks across the Whirlpool may discern a wooded glen running back from the river on the Canadian side. This glen, it is said by geologists, marked the original channel of the river, but, owing to some mighty convulsion of nature, that outlet for the waters of the great lakes was closed and the river was forced to make a new passage for itself through the present channel. In cutting out its new course the waters have worn away the rocks into peculiar and interesting shapes. Not the least interesting of these is the large rock which towers up on the Canadian side just at the angle where the river turns from the Whirlpool to flow onward toward Lake Ontario. For years every photograph taken of the Whirlpool from the American side has shown, apparently carved in the top of this rocky eminence, a strange resemblance to a human face. Within the last few months the action of the atmosphere has crumbled the rock to such an extent that the face is discernible to the naked eye. It has been named "The Demon of the Gorge," and it stands there immovable and inscrutable, keeping watch and ward over the awful secrets of nature and the mysterious Whirlpool.

The Lower Niagara Rapids

Below the Whirlpool the channel through which the waters have to force their way again becomes narrower, and a second set of rapids is formed by the descent of the stream—not so swift nor so tumultuous as the Whirlpool Rapids, but still very swift and strong and of great interest. To this series of lower rapids has been given the name of "Devil's Hole Rapids," the name being that of a historic spot a little farther down the Gorge. The channel of the river is said to be deeper through these rapids than at any other point, but the exact depth cannot be ascertained, because the strong current deflects any sounding apparatus that is used.

Fronting the Devil's Hole Rapids is Ongiara Park. This is a pleasant glen in the woods on the sloping bank above the river, owned by the Niagara Gorge Railroad Company, and used as a picnic grove for passengers by that route.

The Giant Rock

Just below Ongiara Park the Gorge Road passes behind an enormous rock, that rises from the edge of the water and towers high above as the car passes. What cataclysm of nature detached this rock from the cliff above and sent it thundering down the precipice to find a resting place on the river's brink is not known. Ever since white men first explored the Gorge the Giant Rock has stood like a silent sentinel, and when the Gorge Road was built it was decided to leave it where it is, rather than to destroy the ancient landmark.

The Devil's Hole

From end to end the Niagara Gorge teems with historical incident. For the first century and a half after white men took possession of the lands in the Niagara region, there were continual struggles—first between the whites and the savages, later between the English and the French, and latest of all, between the English in Canada and the men of English descent, who had cast their lot with the young American republic. The Devil's Hole, which is reached by an easy ascent from the Gorge Road, was the scene, in 1763, of one of the most awful of the many tragedies of the Niagara region. On the 13th of September in that year a train of British-American troops under Lieut. Don Campbell of the Royal American Regiment, was returning to Fort Niagara from Detroit, where it had been with a load of supplies for the garrison there. Fort Schlosser, now the village of Echota, above the Falls, was reached on the morning of the 13th, and that evening the train set out for Fort Niagara, taking the well-beaten road along the top of the cliff on the American side. Accompanying the troops was John Steadman, one of the first settlers in this region and master of the portage around the Falls. Heedless of impending danger, the caval-

Descent Toward the Head of Whirlpool Rapids—Niagara Gorge Railroad cade traveled along in safety until the cleft in the rocks—since known by the name of the Devil's Hole—was reached, when, without a moment's warning, a large band of Seneca Indians who had been lying in ambush at this point attacked the travelers with guns and tomahawks. Of the ninety persons in the company, all but three were either driven over the precipice to meet a horrible death on the rocks below or killed outright by the savages. One drummer-boy escaped by his drum-straps catching in a pine tree, part way down the cliff, where he hung until rescued. His name was Matthews, and he lived until 1821, when he died in Canada at the age of seventy-four. One driver was wounded and lay concealed in a clump of evergreens, where the blood-thirsty savages overlooked him. Steadman himself who, the Indians said later, seemed to bear a charmed life, spurred his horse through the opposing Indians and made his escape to Fort Schlosser.

The noise of the conflict was heard at Lewiston and two companies of troops which were stationed there came hurriedly up the trail to the rescue of the supply-train. Seeing no enemy, they marched boldly across the little bridge that spanned Bloody Run, a small stream, the dry bed of which may be seen to-day, and when half way across the bridge were themselves attacked by the Senecas, who had hidden in the evergreens as they heard the approach of the troops. Only eight of the soldiers survived this second ambush. The Indians hastily scalped their victims, taking in all eighty scalps, including those of six officers, and mounting the horses that had not been forced over the cliff, went back to their home on the banks of the Genesee. It is only fair to the generally peaceable Seneca nation to say that this attack was made without the knowledge of the chiefs of that tribe, by a band of young braves under the leadership of "Farmer's Brother," a man who afterwards became a leader of his people and a friend of the whites, and who regretted to the end of his life his youthful folly.

After the massacre at the Devil's Hole block-houses were erected at different points along the portage trail, 1,200 yards apart, for the better protection of travelers. The ruins of some of these structures may yet be seen.

Lewiston

Where the splendid steamers of the Niagara Navigation Company's Toronto line touch at Lewiston is the spot where the first white man who ever entered the Niagara River, so far as history tells, landed after sailing up from Lake Ontario. This was in 1678, and the explorer who braved the entrance to an unknown river was the intrepid La Salle. In his search for a portage La Salle ascended as far as the lower rapids. Finding no safe landing place, he returned to Lewiston, and there built a cabin, surrounded by a palisade, as a storehouse and base of supplies for his projected expedition above the Falls, which he had not yet seen. This structure is believed to have been almost at the point where the present dock is. From this point a portage was established, the trail leading up the mountain above Lewiston and traversing the table-land above the cliff to a point above Echota. This trail was followed for many years, or until railroads were built, which made it unnecessary to transport goods by wagon. Farmer's wagons and pleasure vehicles, however, still follow the old road, that runs almost exactly as La Salle laid it out more than two centuries ago.

NATIONAL ELECTROLYTIC COMPANY

THE National Electrolytic Company commenced business in 1898. It has a large plant on the lands of the Niagara Falls Hydraulic Power and Manufacturing Company and is engaged in the electrolytic manufacture of chlorate of potash. The company uses 2,500 horse power, which is transmitted by aluminum cables from Power House No. 2, located at the water's edge in the gorge, to the works on top of the high bank. It is one of the successful electrochemical industries of Niagara Falls.

ACKER PROCESS COMPANY

THE works of the Acker Process Company are located in the lower power district on property bounded by Third street, Walnut street, New York Central Railroad tracks, and by the gorge of the Niagara River below the falls.

The works cover a ground area of about 70,000 square feet. The total power utilized aggregates about 3,800 electrical horse power, and is delivered in the form of direct current, the greater portion being utilized in electrolytic furnaces for the decomposition of sodium chloride. This current of 9,000 amperes and 300 volts is conducted through great bundles of aluminum conductors placed in trenches under ground, leading from the power house in the gorge below the falls to the company's works, a distance of approximately 1,600 feet. The aggregate cross-section of the conductors carrying this current is, of course, very large. The entire current is utilized in a single series or row of furnaces.

The products manufactured by the company are: caustic soda, bleaching powder, tetrachloride of tin (known to the trade as bichloride of tin), oxide of tin, tin crystals, and carbon tetrachloride.

The electrolytic alkali process was the first of the several processes to be installed and put in operation, and is due to Mr. Charles E. Acker. A description of the process was first given at the inaugural meeting of the American Electrochemical Society, at Philadelphia, in 1902, and was published in the Transactions of the Society, Volume I., 1902. An article by Clinton Paul Townsend may be found in the "Electrical World and Engineer" (New York), of April 5, 1902. An article by Professor Haber, being the first part of a report to the German Bunsen Society for Applied Chemistry, on "The Industrial Development of Electrochemistery in America," appeared in the "Zeitschrift für Elektrochemie," beginning April 16, 1903.

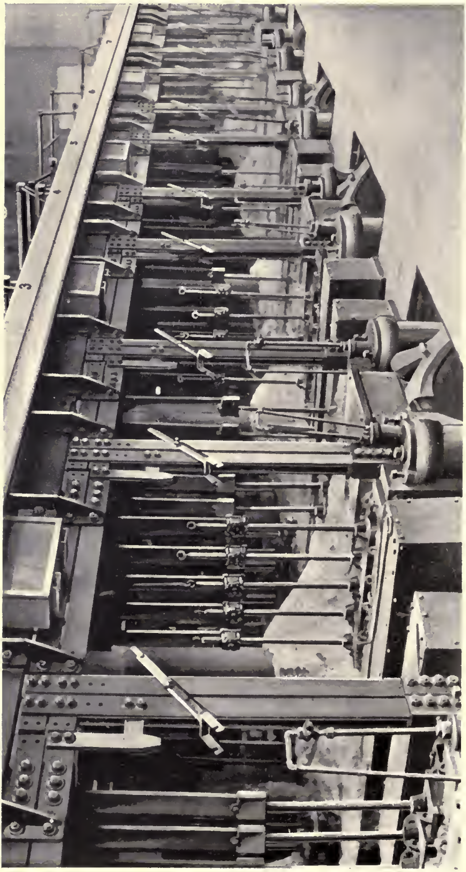
Mr. Acker was awarded the Elliott Cresson gold medal by the Franklin Institute, for his process of

Acker Process Company

producing caustic soda and chlorine by the electrolysis of fused common salt.

Various American and Canadian patents covering this particular process have been issued. The process has also been patented in the principal European countries, the number of such patents aggregating about forty.

A new process for the manufacture of tetrachloride of tin was introduced in the works in 1903, and the company now turns out a considerable proportion of the tetrachloride of tin consumed in the country. The company does not distribute this product



Electrolytic Furnaces—Acker Process Company at retail, but makes shipments in carload lots only. This process, as well as that for the manufacture of tetrachloride of carbon, tin crystals, oxide of tin, etc., is due to Mr. Charles E. Acker. Numerous patents have been applied for in the United States Patent Office, and have been allowed, although they

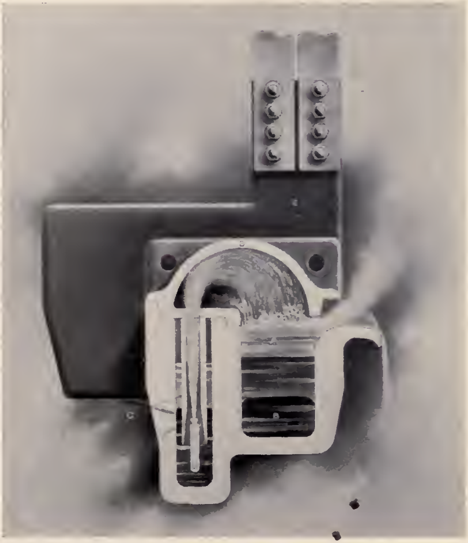


Figure 1

have not been issued. There have as yet been no published descriptions of these methods.

The company's works are illustrated on page 63, and an interior view of the furnace room showing a row of electrolytic furnaces on page 64. Each furnace is here represented with five electrodes or anodes. Since this photograph was taken these anodes have been enlarged, so that there are now four anodes employed in each furnace instead of five. The current of 9,000 amperes passing through the furnaces in series is, therefore, carried by four anodes in each furnace. The normal current carried by each anode is approximately 2,250 amperes. A

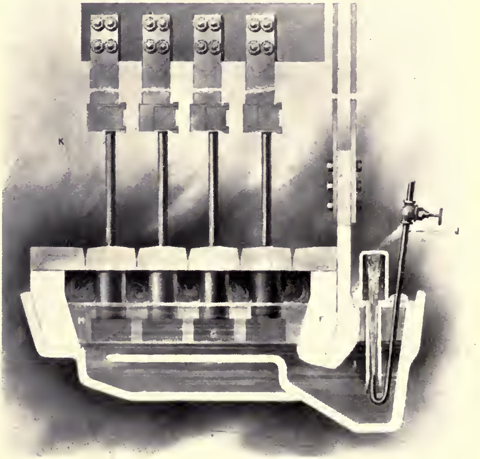


Figure 2

single anode may be removed at any time from a furnace, during which time the current is carried by the three remaining anodes to the extent of 3,000 amperes or more for each anode.

The cathode is of molten lead which is caused to circulate by a jet of steam introduced into a well containing the molten metal at the end of the furnace, shown in Fig. 1. The operation of this steam injector is shown in detail in Fig. 2. The jet of steam issues from a small orifice under pressure, and passes through an injector or converter pipe made of cast iron, which, in practice, is a single casting with the cover D. There are thus only two parts to the furnace, namely, the main casting E, which is lined with ordinary firebrick for containing the molten salt, and the cast iron cover D. The steam passing through the converter carries along

Figure 3

with it more or less of the molten lead in its path. This lead strikes the curved cover and is deflected into the long channel B, through which it passes to the other end of the electric furnace, where it spreads over the hearth and becomes the cathode, taking up the sodium liberated from the salt by the current of 9,000 amperes. The alloy of lead and sodium finally reaches the injector in the course of the circulation, and the sodium decomposes the steam, thereby forming anhydrous caustic soda, hydrogen gas and metallic lead. The hydrogen burns continuously in a large flame, the lead again flows back through the long channel B and the molten caustic soda runs continuously out of the furnace through the overflow spout. The molten caustic soda is now collected from all the furnaces and, while still molten, is conducted to a caustic pot, where it is allowed to settle. This operation goes on continuously twenty-four hours per day, and seven days per week. There is no intermission.

A general idea of the setting of the furnaces is given in Fig. 3, which also indicates the method of taking off the chlorine gas. This is taken away by slight suction through passages in the brick piers between each pair of furnaces.

PART III

AMERICAN NIAGARA POWER DEVELOPMENT BY TUNNEL

Power Houses and Transformer House—The Niagara Falls Power Company

The Niagara Falls Power Company

THE utilization of the power of Niagara Falls has for years been the dream of engineers and of all those interested in industrial development. In the past many schemes for this purpose have been suggested by engineers and inventors, but never, until the advent of the modern era in electrical engineering, has the proposition, on a large scale, been able to stand upon a basis attractive to the capitalist. The difficulty in the past has not been to apply the waters of Niagara for the turning of a water wheel, for many of the schemes then suggested would have accomplished this successfully; but what to do with the power when thus developed at the water wheel shaft was the problem before the engineer. Obviously here the question of transmission arose as of prime importance.

Among the numerous early plans suggested will be found extensive systems of pneumatic tubes operated by turbine driven air compressors, the air pipes leading therefrom to factories located in the vicinity of a power house, each factory having its own air motors thus operated. It may be of interest to note that one of these early plans contemplated the transmission of power to Buffalo by this means.

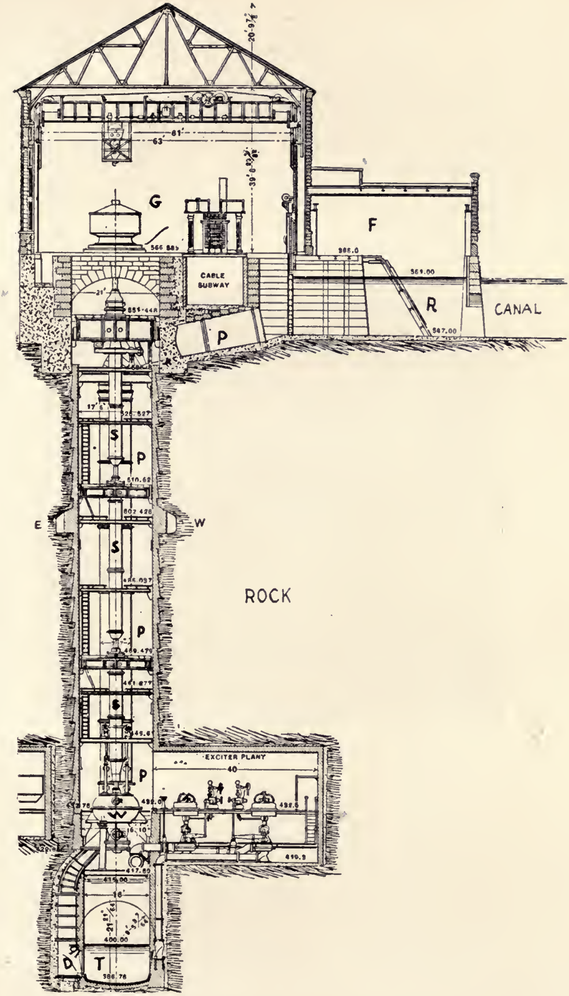
Another plan consisted in lines of countershafting, bracketed on columns, extending radially from a central power station, this long shafting to be driven by water wheels at the power station through a system of gearing. Factories were to be located along these lines of shafting and were to receive their power by clutches connected to these shafts.

Still another plan involved the construction of a network of surface canals fed by a common intake from the upper Niagara River. Factories were to be established along these canals and take water from them for the operation of individual turbines; the dead water to be discharged in branch tunnels connected to a main trunk tunnel leading to the lower river.

These plans now look grotesque, but twenty years ago or so they were seriously considered by good engineers. They were discarded largely for financial reasons, the systems showing low efficiency and high cost of construction and maintenance. The final solution of the problem by electrical methods is almost ideal in its simplicity and efficiency as a means of transmitting the energy of Niagara to the consumers.

In the electrical distribution of Niagara power an essential advantage has resulted which was not fully recognized at the time of its first adoption. As the uses of this power have developed it has been found that not only was *power* wanted for industrial purposes but primarily *electric power.* This is especially true in the case of the electrochemical and electric lighting applications. If pneumatic, hydraulic or mechanical power had been supplied for use, it would have been necessary for all the electrochemical plants to convert the power into electric current, before they could use it, with all the loss in power which would result from this conversion. So also with the electric lighting and electric railway applications, where power is wanted in the form of electric current.

The general construction and organization of apparatus adopted by The Niagara Falls Power Company for utilizing the hydraulic energy of the Falls is as follows: A short canal has been excavated at a point about one mile above the Falls on the American side, its direction being approximately at right angles to the river. This canal leads the water into two power houses located on opposite sides. From the canal the water flows into penstocks and thence to the turbines, which are installed



Transverse Section of Power House No. 2
The Niagara Falls Power Company

near the bottom of the two wheelpits excavated out of solid rock under the two respective power houses. After passing through the buckets of the turbines and giving up its energy thereto, the water is discharged into a tunnel about twenty-one feet in diameter, which carries it off under the city of Niagara Falls, a distance of approximately 7,000 feet, to the lower river. Each turbine is direct con-

Interior of Power House No. 1
The Niagara Falls Power Company

nected through a hollow vertical shaft to an electric generator installed above near the ground level.

Power House No. 1, which was the first to be constructed, contains ten vertical shaft turbines, each direct coupled to an alternating current generator of 5,000 h.p. capacity. Power House No. 2, which was completed early in 1904, contains eleven generating units of the same capacity, making a total capacity for the two plants of 105,000 e.h.p.

The illustration shows Power House No. 2 in section and illustrates the general arrangement of apparatus as adopted in both plants. From the canal the water flows through submerged arches into an enclosed forebay F. Thence through the racks R the water enters the penstock P and flows downward through it to the wheel case W. From the wheel case it is forced at a pressure of about fifty pounds per square inch inwardly through the buckets of the turbine and out through the draught tube D into the tail race T, and thence through the tunnel to the lower river.

Power House No. 1 differs from this arrangement hydraulically in that the turbines discharge their water into the tail race openly without draught tubes.

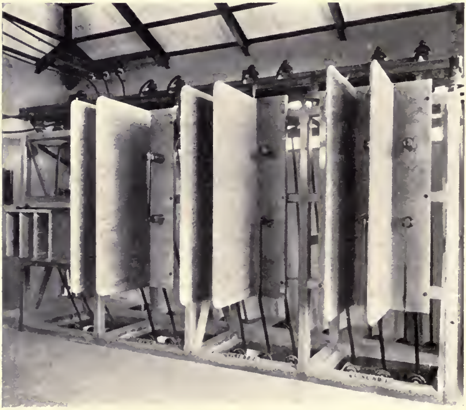
In both power houses the electric generators are of the alternating current type, wound for 2,200 volts, 2-phases, 25-cycles, and operate at a speed of 250 r.p.m.

In the older plant the alternators are all of the external revolving field or umbrella type, while in Power House No. 2 the last five machines are of the internal field construction. This internal field arrangement affords several advantages of simplicity and of accessibility to the various parts of the machine.

In general construction and method of operation the two power houses are very similar, the structural changes introduced in No. 2 being principally along the line of improvements in detail, which are the result of the evolution which has taken place in engineering methods since the first plant was installed.

When the first power house at Niagara Falls was proposed for a capacity of 50,000 h.p., with an ultimate tunnel capacity of 100,000 h.p., many people wondered how it would be possible to dispose commercially of such a large amount of electric power. Central station managers who, after a strenuous canvass for new customers, had been accustomed to increasing the output of their plants by the addition of a 150-kw. Edison bi-polar machine, were staggered by the magnitude of the quantities involved in this new proposition. Skeptical opinions were expressed based upon industrial and electrical conditions then existing, and these opinions at that time were, in the main, justifiable.

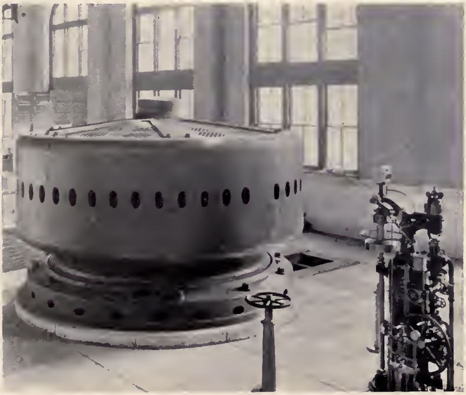
Since that time, however, great developments have



22000 Volt Switches and Bus-bars at Tonawanda Section House
The Niagara Falls Power Company

taken place in the electrical arts which have made possible the present realization of such a demand for power. The developments which have created this demand have been, first of all, in electro-chemistry, though the output of the Niagara plant is not confined to electro-chemical applications, as is generally supposed. Large blocks of its power are in use for electric railway propulsion, electric lighting, and mechanical power application. One of the most recent and important factors in the growth of this power system has been the introduction of the electric motor drive for factory appliances. The evolution of economical methods in power transmission has made the delivery of Niagara power commercially possible to a widely scattered market.

As a result of these developments in the application of electrical energy the first power house has



Internally Revolving Field 5000 H. P. Alternator and Hydraulic Governor in Power House No. 2 of The Niagara Falls Power Company

reached the limit of its capacity of 50,000 h.p. and the second plant, having a capacity of 55,000 h.p., is well along towards its limit.

The electrical energy starts from the bus-bars of the power house at a pressure of 2,200 volts, two-phase, 25-cycles, constituting, so to speak, the raw material upon which the various transformations are subsequently made. From the bus-bars the system divides into three distinct classes of service.

The first of these embraces the local distribution

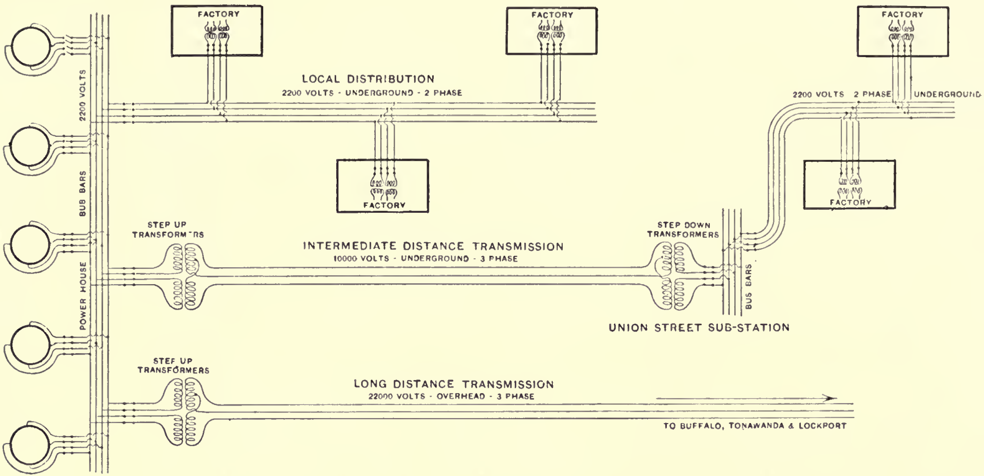


DIAGRAM ILLUSTRATING THE GENERAL SCHEME OF POWER DISTRIBUTION OF THE NIAGARA FALLS POWER COMPANY to factories which are in the immediate neighborhood of the power house, these customers being supplied by underground cables directly from the bus-bars at the generator voltage, phase and frequency.

The second class might be termed the intermediate-distance transmission.

In this case, the 2,200-volt, two-phase current, immediately after leaving the power house bus-bars, is transformed to 11,000-volt, three-phase current by means of step-up transformers, and transmitted underground to a step-down transformer station about two miles from the power house. There it is reconverted into 2,200-volt, two-phase current, and is distributed, as in the first system, for various factory uses by means of underground cables. This system is used to supply factories whose distance from the power house renders it cheaper to buy step-up and step-down transformers and transmit at a high voltage, than to buy the copper necessary to supply them with power directly from the power house bus-bars at 2,200 volts. The object in transforming into three-phase current in this system and back again into two-phase at the step-down station is to effect the saving in copper resulting from the use of the three-phase transmission, which amounts to twenty-five per cent., while maintaining the service to all factories uniform at 2,200-volt, two-phase current. In all the underground distribution, conduits are used with the cables drawn through ducts in the usual manner.

In the third class we have long-distance transmission. Here the 2,200-volt, two-phase current is transformed at the power house to three-phase current at 22,000 volts and distributed on overhead bare conductors to points at a considerable distance from Niagara Falls, such as Buffalo, Tonawanda, and Lockport. The three-phase system is also used in this case on account of the saving in copper.

The long-distance transmission is operated over three separate circuits, each having a length to the Buffalo city line of about twenty-two miles. Two of these circuits are of 350,000 cir. mil. stranded copper installed on the same pole line. The third circuit is strung upon a separate pole line throughout its entire length, and is of aluminum instead of copper. This aluminum line has the same resistance as each of the other two, and is composed of three cables of

The Step-Up Transformer Plant of The Niagara Falls Power Company, Containing Transformers Having Aggregate Output of 60,000 H. P.

500,000 cir. mil. each, made up of thirty-seven strands. At the present market price of copper wire it is cheaper to use aluminum for overhead lines where the conductors do not have to be insulated. The conductivity of aluminum is less than copper, and the price per pound is greater, but the volume per pound of aluminum is much greater than that of copper on account of the lower specific gravity of the metal. When, therefore, resistance per pound is taken as the basis for comparison, aluminum is found to be cheaper. Furthermore, on account of the increased section of the aluminum conductor and its greater lightness, it is better able to resist span strains due to gravity than a copper conductor of the same resistance. It is interesting to note that the aluminum of which these cables are made is the product of the plant of the Pittsburg Reduction Company, which is operated by Niagara power.

The capacity of the three Buffalo circuits is approximately 10,000 h.p. each at 22,000 volts.

The Niagara Falls Power Company's distributing system now covers a very large territory; thousands of people are dependent upon it in their daily lives, and commercial interests of great importance are involved in it. The industrial world has learned that the Niagara power enterprise is no longer an experiment, and that it has already become an important factor in the manufacturing status of this continent. Its extent and the great variety of the industries which it supplies will be seen from the list which follows:

THE NIAGARA FALLS POWER COMPANY—LIST OF USERS

NIAGARA FALLS, N. Y.

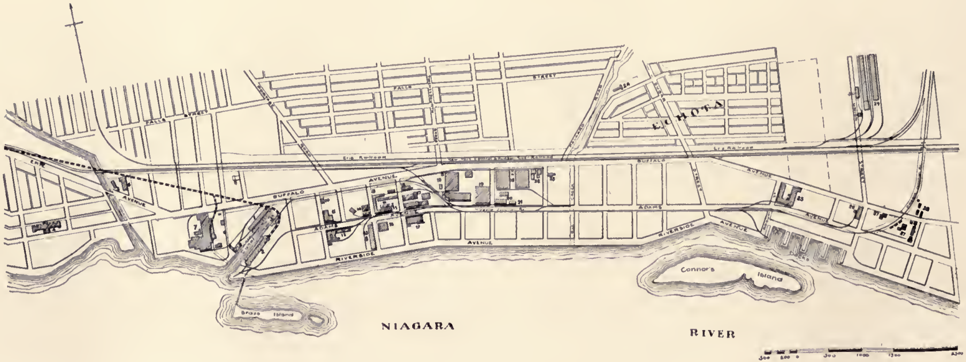
Name	Maximum Power H.P.	Transmission Dist. Miles
The Pittsburg Reduction Company	8,000	0.46
The Carborundum Company	5,000	0.38
Union Carbide Company	15,000	2.
Niagara Electro-Chemical Company	2,000	0.75
Niagara Falls Lighting Company	1,000	0.14
International Railway Company	1,500	..
The Niagara Falls Water Works Company, hydraulic power	300	..
International Paper Company, hydraulic power	8,000	..
Castner Electrolytic Alkali Company	7,000	0.85

Name	Maximum Power H. P.	Transmission Dist. Miles
Niagara Development Company........	100	1.23
Oldbury Electro-Chemical Company...	1,500	2.18
Electrical Lead Reduction Company...	500	0.19
International Acheson Graphite Co....	1,000	0.28
Acetyvone Manufacturing Company....	50	0.95
Roberts Chemical Company...........	500	1.90
Francis Hook and Eye and Fastener Co.	15	0.47
Norton Emery Wheel Company........	650	0.95
The Natural Food Company...........	1,500	0.66
Ramapo Iron Works..................	500	1.70
By-Products Paper Company..........	500	0.19
Composite Board Company............	200	0.34
Atmospheric Products Company.......	50	0.47
Niagara Research Laboratories........	500	0.28
NIAGARA FALLS, ONTARIO		
A. C. Douglass, contractor.............	400	3.
M. P. Davis, contractor................	300	3.7
A. C. Jenckes, contractor..............	200	3.5
The Carborundum Company...........	200	3.6
Niagara, St. Catharines and Toronto Ry.	500	3.8
Lighting Company	500	3.4
TONAWANDA		
International Railway Company.......	1,500	
Tonawanda Board and Paper Company	1,200	15
Buffalo Bolt Company.................	160	14
Philip Houck Milling Company........	142	14
F. J. Alliger Company................	107	15
Adamite Abrasive Company...........	50	14.5
Orient Manufacturing Company.........	20	14
Felton School	22	14
LOCKPORT		
Lockport Lighting Company...........	500	25
International Railway Company........	1,000	26
OLCOTT		
International Railway Company........	1,000	39

Power House No. 2—The Niagara Falls Power Company

BUFFALO

Name	Maximum Power H. P.	Transmission Dist. Miles
Buffalo Railway Company	7,000	27
Buffalo General Electric Company	6,000	27.6
The Charles G. Curtiss Company	125	25.5
McKinnon Dash Company	100	24.4
Pratt & Letchworth	233	24.5
W. W. Oliver Manufacturing Company	15	24.7
Acme Steel and Malleable Iron Works	50	24.8
N. Y. Car Wheel Works	200	24.3
National Battery Company	90	26.3
Standard Plaster Company	100	25.5
Great Northern Elevator Company	900	29.5
Buffalo Dry Dock Company	133	30
Electric Grain Elevator	200	30.7
Barcalo and Boll Manufacturing Co	60	30
Schoellkopf & Company	50	30
Iron Elevator and Transfer Company	165	30
Great Eastern Elevator	900	30
Sidney Shepard & Co	100	30
J. I. Prentiss & Co	30	29
Edward Elsworth & Co	150	30
American Agricultural Chemical Co	125	32
Jacob Dold Packing Company	100	32.5
Empire Bridge Company	90	33
Buffalo Elevating Company	950	29
John Kam Malting Company	225	24.3
American Brake Shoe and Foundry Co	40	33.2
Buffalo Cereal Company	375	30.3
Taylor Signal Company	65	25.5
Snow Steam Pump Works	150	33.3
Wood & Brooks Company	100	24.4
U. S. Rubber Reclaiming Works	995	31.7
American Radiator Company	200	24
Cumpson-Prentiss Coffee Company	30	29.1
Duffy Brothers & Nellis	50	33.5
Buffalo Foundry Company	240	35.1
H. O. Mills	255	29.3
Jewett Manufacturing Company	30	24.8



EXPLANATORY TABLE

1 Power House No. 1
2 Power House No. 2
3 Main Transformer Station
4 The Natural Food Co.
5 Francis Hook & Eye & Fastener Co.
6 Niagara Surface Coating Co.
7 International Paper Co.
8 Buffalo and Niagara Falls Electric Light and Power Co.
9 The Niagara Falls Water Works Co.
10 Niagara Research Laboratories
11 Electrical Lead Reduction Co.
12 By-Products Paper Co.
13 Composite Board Co.
14 International Acheson Graphite Co.
15 The Carborundum Co.
16 Atmospheric Products Co.
17 The Pittsburg Reduction Co.
18 Castner Electrolytic Alkali Co.
19 Niagara Electro Chemical Co.
20 The United Barium Co.
21 Ampere Electro Chemical Co.
22 Norton Emery Wheel Co.
23 Acetyvone Manufacturing Co.
24 Echota Disposal Works
25 Ramapo Iron Works
26 Roberts Chemical Co.
27 Oldbury Electro-Chemical Co.
28 Phosphorus Compounds Co.
29 Union Carbide Co.
30 Union Street Substation

Map Showing Location of Local Tenants on Lands of the Niagara Falls Power Company

Name	Maximum Power H. P.	Transmission Dist. Miles
Buffalo Pitts Company	187	35.5
Buffalo Brake Beam Company	30	25
Buffalo Dental Manufacturing Company	20	35.5
Keystone Manufacturing Company	25	24.8
R. L. Ginsburgh & Sons	33	34
Buffalo Weaving and Belting Company	65	25.5
H. W. Dopp & Co	10	25
Frontier Iron Works	15	25
The Crosby Company	50	33
Lackawanna Steel Company	70	29.4
West Manufacturing Company	40	28
Buffalo Gasoline Motor Works	20	25
Pratt & Lambert	10	24.5
Wegner Machine Company	40	29
Spencer Kellogg Company	500	29.2
Hygiene Food Company	300	32.3
Collins Baking Company	50	33.2
George Urban Milling Company	450	34.5
Niagara Mill and Elevator Company	100	26
D. L. & W. R. R. Shops	150	34.5
Ryder Belt and Cordage Company	65	24.7
United States Headlight Company	40	26
George E. Laverack Building	100	28.2
Buffalo Structural Steel Company	30	26
J. N. Adam & Co	100	28.2
Genesee Hotel	100	28.1

The figures given are for maximum power used in each case. Since the maximum in the various plants does not occur at the same time, the resultant maximum at the power house is somewhat less than their sum. At present it amounts to about 75,000 e.h.p.

On a large system of electric power distribution, such as that of the Niagara Falls Power Company, the power users have necessarily widely differing requirements and comparatively few utilize the electric current in the exact form in which it leaves the terminals of the generators. A large variety of secondary and tertiary systems are therefore derived by transformation and conversion. The following are some of the systems thus derived from the primary supply mains at 2,200 volts, 2-phase, 25-cycles:

25 CYCLE

2,200 volts	3-phase
22,000 volts	3-phase
11,000 volts	3-phase
4,500 volts	3-phase
350 volts	3-phase
350 volts	2-phase
110 volts	single-phase
30 volts	single-phase

60 CYCLE

2,200 volts	2-phase
8,000 volts	single-phase (arc).
110 volts	2-phase

125 CYCLE

2,200 volts	single-phase
8,000 volts	single-phase (arc).

DIRECT CURRENT

100 volts	130 volts
160 volts	250 volts
550 volts	8,000 volts (arc)

All these systems are derived by simple transformations by means of transformers, rotary converters, or motor-generator sets.

Such then is the present status of the power system of the Niagara Falls Power Company, and a glance at its past development indicates the lines along which it is likely to grow in the future.

When the Canadian plant is completed The Niagara Falls Power Company and the Canadian Niagara Power Company will have available three large independent power houses for the operation of their system and will be the only power companies having more than one power house for the protection and assurance of continuous supply of power. This is a matter of great importance to customers. In case of some unforeseen accident to any one of the plants, interconnections can at once be established

Interior of Power House No. 2
The Niagara Falls Power Company

so that the most important users of power supplied normally by the disabled plant can be supplied with power from the other two without interruption. This is especially important where the public utilities are involved, such as the electric railways and electric lighting companies. As the manufacturing arts advance, the element of power becomes more and more important and cheap power therefore more demanded. Electro-chemistry is a new art, and one which has great possibilities ahead of it. The high temperatures obtainable in electric furnaces have opened up a new field to chemical synthesis, and it is likely that many as yet undiscovered processes, which will require large amounts of electrical power for their operation, will be brought to light. The supply of power for electrochemical purposes is especially desirable in a water power plant where large investment is necessary, for the power used by these processes is practically constant for twenty-four hours of the day, thus tending to reduce load "peaks" on the total station output.

The economical distance to which power can be transmitted extends every year as the general demand for power increases and methods of handling high voltages improve, and the electric equipment of steam railway systems, which is certain to come in time, will open up a further field for the long-distance transmission of large amounts of power from a central point.

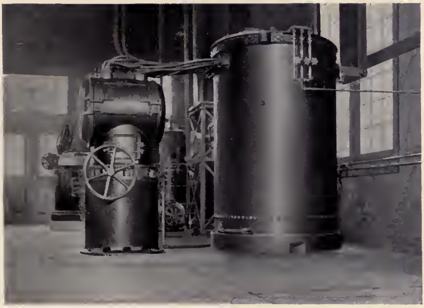
All these tendencies in industrial conditions, which have been mentioned, result in an accelerating demand for power from Niagara Falls.

1893—1903
The Carborundum Company

Local Tenants of the Niagara Falls Power Company

THE CARBORUNDUM COMPANY

THIS company takes its electrical power from The Niagara Falls Power Company. It located at Niagara in 1895, having been the second customer to make a contract with the Power Company.

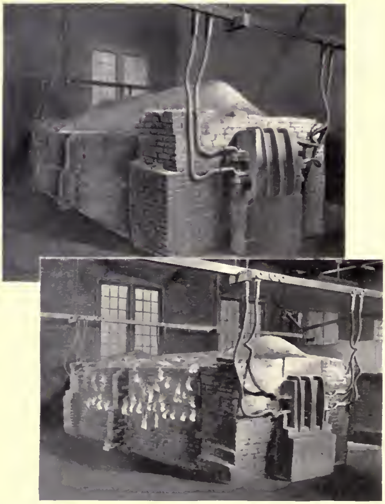


1000 H. P. Transformer with Induction Regulator
The Carborundum Company

The Carborundum Company manufactures, under the trade-mark of "carborundum," silicon carbide and its by-products.

Carborundum is a chemical combination of carbon and silicon, which elements are obtained from coke and sand; these materials being fused in an electric furnace at an estimated temperature of about 7,000° fahr.

The Carborundum Company was incorporated in 1891, and carried on its earlier operations at Monongahela, Pa., where furnaces using 120 e. h. p. were employed, the electrical energy being developed by generators driven by steam.



Furnace Ready for Burning
Furnace During Burning
The Carborundum Company

On locating at Niagara Falls in 1895, the first installation was a unit of five furnaces, these being operated successively one at a time. The current used was 1,000 e. h. p., received on the premises of the company at 2,200 volts and transformed down to 150 volts, from which point it could be regulated in one-half volt steps between 100 and 200 volts. At the time of the installation the transforming apparatus was the largest in the world.

In 1899 a second, and in 1902 a third unit of 1,000 e. h. p. were put into operation; the transforming apparatus being of practically the same type as that of the first unit.

In April, 1904, 2,000 additional e. h. p. were taken on. This is used as one unit, handled through one transformer and regulator, which is believed to be the largest regulated transformer in the world.

The Carborundum Company is now using three units of 1,000 e. h. p. and one unit of 2,000 e. h. p., which are used continuously twenty-four hours per day and 365 days per year.

The company's plant covers eight acres of ground and consists of a series of brick buildings having a

Furnace After Burning
The Carborundum Company

total floor space of 221,009 square feet, and being especially adapted to the various purposes of crushing and mixing raw materials, operating furnaces, grinding, washing and sifting the carborundum, and of making the carborundum into the various marketable forms of wheels, stones, paper, cloth, etc.

The principal characteristics of caborundum are hardness, brittleness, infusibility and insolubility. In hardness carborundum ranks next to the diamond; and this, with its other properties, makes it peculiarly adaptable to its principal use as an abrasive or grinding material.

Other uses to which carborundum has been put are for furnace linings and for various refractory purposes where a great heat resistance is required; and for increasing the fluidity of molten metals, or adding to their silicon content.

Quite recently the company has produced large quantities of pure metallic silicon. This metal, which now sells as a laboratory curiosity at $7.00 per ounce, can be manufactured in unlimited quantities at approximately 25 cents, or one shilling per pound.

UNION CARBIDE COMPANY

THE plant of the Union Carbide Company is one of the largest on the lands of the Niagara Falls Power Company. It is located about one and one-half miles east of the power stations, the site occupying about eight acres. The buildings are of brick and steel, covering a space over 200 feet wide and more than 880 feet long.

In the manufacture of calcium carbide, the raw materials used are burnt lime and ground coke, the proportions of these materials being about one of lime to two-thirds of coke. The temperature at which calcium carbide is formed is very high compared with metallurgical electric-furnace work, and is far higher than can be obtained in the ordinary combustible-heated furnace. It is, however, below the temperature used in the manufacture of artificial graphite, siloxicon or carborundum.

The power supply of the Union Carbide Company is transmitted to the works over cables laid in an underground conduit. The company uses alternating current at 2,250 volts. At present approximately 15,000 h.p. is used. In the works the company has installed ten 2,000-h.p. transformers, and two 500-h.p. transformers, as well as about 40 motors ranging from one to 200 h.p.

There are 72 furnaces, more than 50 of which are in operation. These furnaces are circular in form and of

Niagara Falls Works of the Union Carbide Company iron, each having a recessed rim, to the top of which are bolted segmental wings. In the space thus formed two carbons are placed at the top of a wheel. The charge of lime and carbon there fed to them is fused by the arc formed by the current passing from one carbon to the other. The furnace revolves slowly on trunnions, making an entire turn once in forty-eight hours, and the fluid carbide resulting from the action of the arc, as above described, is thus taken out of the field and solidifies. The ingots are taken from the lower side of the wheel comparatively cold, and from 24 to 30 inches thick. In diameter the furnaces are about ten feet, each furnace taking about 2,000 amperes at 110 volts, or about 300 h.p., to operate it. The output of each furnace is about one ton per day.

The Niagara Falls plant of the Union Carbide Company is known as Plant No. 1, and was erected in 1899. Plant No. 2 is located at Sault Ste. Marie, Mich. The site at the "Soo" covers ten acres, and the buildings are even larger than those at Niagara Falls, one having a length of 725 feet with a width of 75 feet, while another is 680 feet long and 75 feet wide. At the "Soo" the company has a contract for 20,000 h.p., and owns its own electric generating plant, as well as a lime burning plant. An interesting point in connection with the "Soo" works is that all the coke and coal used is secured during the summer season when lake navigation is open.

Calcium carbide and the great industry that has developed through its manufacture owe their existence to an accidental discovery made in 1892 at an aluminum works in Spray, N. C. At that time an effort was being made to reduce lime by carbon in order to make calcium, which it was hoped would prove an aid in the reduction of aluminum. While these experiments were in progress, it was discovered that the carbide product gave off an inflammable gas when it came in contact with water. An analysis resulted in its recognition as calcium carbide, an article of great commercial value. Later its manufacture was begun on a commercial scale, and to-day the Union Carbide Company, which controls calcium carbide manufacture in the United States, has warehouses in forty cities and its main offices in New York City and Chicago.

Ingots of Calcium Carbide
Union Carbide Company

Calcium carbide furnishes upwards of five cubic feet of acetylene gas per pound. This gas burns with a soft, steady, brilliant flame, and its use is now very extensive. It has won favor for town lighting and is utilized in illuminating large buildings, houses, and grounds. Its use in portable lamps is very extensive.

BUFFALO AND NIAGARA FALLS ELECTRIC LIGHT AND POWER COMPANY

THE Buffalo and Niagara Falls Electric Light and Power Company acts as a distributing agent of Niagara power in the city of Niagara Falls, and supplies current for all commercial and municipal lighting. The company's station is located on Fourteenth street, near Buffalo avenue, and receives through underground cables, 2-phase, 25-cycle current at a potential of 2,200 volts from The Niagara Falls Power Company. Westinghouse induction motors, direct connected to General Electric rotary field generators, transform this current to single-phase, 2,200 volts, 125-cycles, for use in both arc and incandescent lighting of the southern and central portions of the city. The municipal street lighting is accomplished by means of 7½ ampere, series, alternating, arc lamps operated from constant current transformers, and the commercial lighting from single-phase, primary circuits which are stepped down from 2,200 volts to 108 volts. Direct current for power purposes is delivered at 500 volts, and is obtained from air-blast transformers in connection with synchronous converters.

Three-phase, 25-cycle, alternating current for power purposes will be distributed from this station at 2,200 volts.

The company has a rotary field, single-phase alternator directly connected to an I. P. Morris turbine in the plant of The Niagara Falls Hydraulic Power and Manufacturing Company. The output of this generator is distributed single-phase at 2,200 volts for commercial lighting in the northern section of the city.

Niagara Falls Plant of the Niagara Electric Chemical Co.

THE NIAGARA FALLS WATER WORKS COMPANY

ALTHOUGH a small user of power, The Niagara Falls Water Works Company is one of the most important clients of The Niagara Falls Power Company. The entire southerly half of the city is supplied with water for domestic and manufacturing purposes from the plant located near the southerly end of the Power Company's canal. This district includes all of the large manufacturing plants located in the upper power district. As a reliable supply of water is essential to the processes of many of these plants, it will be seen that the importance of the water works is second only to that of the power plant itself. Foreseeing the necessity of a water supply other than that of the municipal plant, which supplies the other end of the city, The Niagara Falls Power Company early interested itself in the private plant, held a controlling interest in it for a number of years, and supplied all the necessary capital for extensions, but after the mains had been extended so as to assure a proper water supply for manufacturing purposes and fire protection for all its tenant companies, the Power Company sold the water works plant in 1903 to the Western New York Water Company of Buffalo, and the Power Company has no longer any interest in the plant except as a tenant company.

A few mains had been laid in the southern half of the village of Niagara Falls as early as 1877, but it was not until 1892 that the main arteries were laid and connected to a new pumping station, and to a standpipe located at a high elevation. One of the most important mains then laid was that extending past the principal factory sites to the industrial village then being built at Echota. The marvelous growth of the city has necessitated numerous extensions of the earlier system, until at the present time the Water Works Company has nearly twenty-five miles of mains, thus adding in no small degree to the prosperity of industrial Niagara.

The growth of the pumping plant has been commensurate with the demands brought upon it. Commencing in 1892 with a small wooden building housing three 100 h. p. boilers and two 3,000,000 gallon compound duplex steam pumps, a handsome brick building 78 by 142 feet was erected in 1895-96. Realizing the necessity of furnishing pure and wholesome water The Niagara Falls Water Works Company installed in this building a mechanical filtration plant of the Morrison-Jewell type, having a rated capacity of 4,500,000 gallons per day, complete with all accessories. Water taken from the canal of The Niagara Falls Power Company is raised to the top of the filters by centrifugal pumps, direct-connected to electric motors. After being filtered the water flows to a clear water basin, from which it is taken to the pump suction.

Finding the capacity of its pumping plant overtaxed, and realizing the superiority of water to steam as a motive power, the Water Works Company in 1900 installed in wheelpit No. 1 of The Niagara Falls Power Company, two 6,000,000 gallon Riedler pumping engines, direct-connected to 400 h. p. Pelton water-wheels. These pumps are installed in chambers 16 by 35 feet cut from the solid rock, the head of water upon the wheels being about 120 feet. Such an installation was somewhat novel, but has proven entirely successful, requiring but a minimum of repairs. As up to the present time the city has no steam fire engines it was necessary that the pumps should be capable of a sudden increase of pressure on the mains in case of fire. This is accomplished by providing each wheel with two nozzles, one of which is ordinarily employed, while the other is used only in case of fire. By this means the pressure can be practically doubled in less than two minutes, or before the fire department reaches the scene of the fire. An unusual feature of these pumps is that they operate under a suction head of about 120 feet from the main connected with the clear water basin at the filtration plant. The loss in head due to the location of the pumps in the wheelpit is, therefore, only that due to the frictional losses in the pipes as the water flows to and from the pumps.

To measure the water pumped, a 24-inch Venturi meter has been installed. To this is attached the first automatic recording device ever placed in commercial service. This device indicates every ten minutes the rate of pumping. The pumping plant is of up-to-date construction in all respects and corresponds with the industrial progress everywhere apparent in the principal power centre of the country.

THE INTERNATIONAL PAPER COMPANY

A SMALL portion of the water diverted from the upper river by the Niagara Falls Power Company is used to operate the Niagara Falls Mill of the International Paper Company, which is located on a site reclaimed from the river west of Power House No. 1. This Company has built its own wheelpit, and the discharge from its turbines reaches the main tunnel through a lateral tunnel 7 feet in diameter and 600 feet long.

The International Paper Company was incorporated under the laws of the State of New York, January 28, 1898. It acquired at the time of its incorporation almost all the important mills which manufacture news paper in the Eastern States, and, since its incorporation, it has acquired by purchase several additional paper and pulp mills, wood lands, water-powers and other properties. Its manufacturing plants, water-powers and wood lands are located in the States of New York, Maine, New Hampshire, Vermont, Massachusetts, Michigan, and in Canada. It also owns a controlling interest in the following companies: The Continental Paper Bag Company, Rumford Falls, Me., which has a capacity for making upwards of 12,000,000 bags per day; the St. Maurice

The International Paper Company

Lumber Company, which conducts wood operations and operates saw mills in Canada, having a capacity of 30,000,000 feet of lumber per year, in addition to handling pulp wood which is imported into the States for the use of some of the mills of the company; the American Realty Company, which owns wood lands and conducts wood operations in Maine; the Michigan Pulp Wood Company, which conducts wood operations in Michigan and Central Canada, amounting to 27,000,000 feet per year; the American Sulphite Pulp Company, which controls the most valuable patents connected with the process of making sulphite pulp; and the Winnipiseogee Lake Cotton and Woolen Company, which owns hydraulic developments controlling headwaters of the Merrimac River. It also controls other companies owning wood lands, water-powers and valuable franchises.

The authorized capital stock of the company is $25,000,000 preferred, of which $22,406,700 is issued, and $20,000,000 common, of which $17,442,800 is issued.

In considering the application of Niagara power to paper-making it is most interesting and instructive to note that before paper came into existence, many other materials, among them stone, metals and clay, had been used to preserve the records of the past. Then came papyrus, the connecting link between such crude materials and what might properly be called "paper." Papyrus was the pith of an ancient Egyptian plant—the bulrush of the Nile—cut into strips or ribbons, laid side by side crosswise, and pressed together; whereas the most distinctive feature of what we know as paper is that the original structure of the material from which it is made is destroyed by making it into pulp, the fibres then being reconstructed into sheet form.

It is probable that paper, as thus distinguished, originated in China about 150 A. D. Several centuries afterwards the Arabs, during their conflicts with the Chinese, learned the art of paper-making; from the Arabs in turn that knowledge was gained by the Crusaders, and thus the art was introduced into western Europe by way of Syria, Palestine and Byzantium. On the other hand, the

Arabs, in their conquests of Spain, carried the practice of paper-making to that country, so that it reached Europe through two avenues. France first learned to make paper in 1189 A. D., and England not until two or three hundred years later.

Up to the beginning of the present century the method of making paper had been practically the same the world over and the same as practiced originally by the Chinese, fibrous materials being beaten into a pulp, which, mixed with water, was moulded into sheets, all by direct manual labor; but in 1804, a machine, which had been invented in France a few years before, was put into successful operation in England. The machine bears the name, to this day, of the original makers, "Fourdrinier," not that of the inventor, Roberts.

This machine multiplied the productive capacity of labor a thousandfold, and produced a continuous web of paper instead of single sheets. Fundamentally, the process to-day is the same as it has been for the past century, although great improvements have been made in the machinery, very radical changes in the raw material and vast progress in the rapidity and scale of manufacture.

Paper, like all other fabrics, is divided into different classes, depending mainly upon the use to which it is put. Broadly speaking, paper is used for three purposes; writing, printing, and mechanical, such as wrapping. Printing paper is the most important class. This may be further divided into paper for printing newspaper and paper for printing books and other publications, although there is no hard and fast line between the two grades. The newspapers consume one-quarter of all the paper manufactured in this country. News paper is the principal product of the International Paper Company and the exclusive product of its Niagara Falls mill.

Until the last half century, practically all kinds of paper had been made from rags; but since then, various inventions have led to the almost complete substitution of wood fibres in the making of many grades, especially news paper. These inventions related to the processes by which vegetable fibrous substances from their natural state are transformed into pulp. The processes are mechanical and chemical.

The mechanical process consists essentially in disintegrating wood by grinding; thereby the whole structure of the wood, except the bark, is reduced to pulp.

The chemical process which is used in making news paper is known as the "sulphite" process, and consists of treating wood with a solution of sulphurous acid in water, heated in a closed vessel under pressure sufficient to retain the acid gas, until the inter-cellular matter is dissolved, leaving the fibres intact.

Mechanical or ground wood pulp, although invented in Germany in 1844, was first made by the present process in this country in 1867, at Stockbridge, Mass. The sulphite process was invented in America in 1867, and the first sulphite pulp made in the United States was made in 1884 at Providence, R. I. Pulp prepared in these two ways is the basis of most of the news paper made in this country.

Paper was made in America first in 1690 at Germantown, Pa., by William Rittenhouse. To-day the United States manufactures more news paper, as well as more paper in general, than any other country in the world, and also more per capita, which is of much significance, since it is said, "The consumption of paper is the measure of a people's culture."

There are in operation in the United States 1,178 paper and pulp mills, and their annual output of paper is about 2,500,000 tons, which is estimated to be worth upon the market not less than $200,000,000. It may aid to a conception of what this means to say that the quantity of paper produced annually in the United States is 400,000 tons more than the annual production of cotton in the United States and four times the annual consumption, being equal to the annual consumption in the United States of all kinds of fibres, including cotton, wool, jute, flax, etc.

Regarded as a whole, the mills of the International Paper Company balance each other so that any lack in one respect at one mill is offset by a corresponding advantage at another. The properties of the company, however, are so scattered that it is difficult to get a comprehensive idea of them or to appreciate their extent. It may be well to describe them as though they were all consolidated into one property; in other words, to imagine a composite picture of them all and, where possible, to reduce them to the still more concrete form of statistics. As in other kinds of manufacturing, it is essential that paper mills should be located, not only with reference to cheap power and labor, but near the source of the principal materials used. An outline sketch of news paper-making will serve to connect these facts.

As wood is the most important component of news paper, it will be interesting to consider the resources of the company in respect to that material. It comes first from the lands which the company owns in fee, which let us regard as one tract of forest containing nearly 900,000 acres. Another source is lands, the timber on which has been sold to the company under contracts extending over long terms. These contracts cover the wood upon a tract of about 200,000 acres. A third source is wood lands in Canada, on which the company has the exclusive right to operate. These amount to about 1,730,000 acres. All these three sources together are equivalent to a tract one mile wide and about 4,000 miles long, which would reach from Newfoundland to New York, and thence to San Francisco. In addition the company buys a large portion of its supply in the open market, thus conserving its own resources. The wood is conveyed to the mills either by driving in the river or by rail. If shipped by rail, the annual supply would fill 63,500 freight cars, making a train 480 miles long.

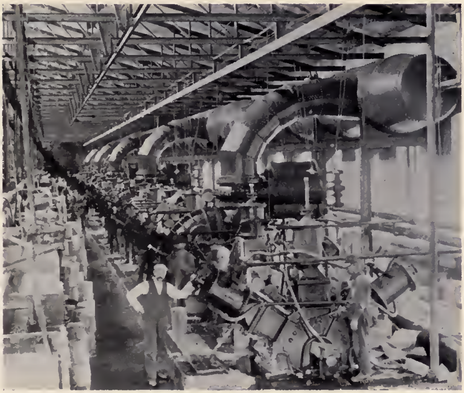
Imagine a mammoth paper mill operated by 150,000 horse power, which would be 45,000 horse power more than is developed in the two power houses of the Niagara Falls Power Company. This amount of energy rented at $18 per year for a twelve-hour day would represent a rental of $5,400,000, or ten per cent. on $54,000,000. Then add to this picture another 100,000 horse power, representing the undeveloped water-powers of the company, held in reserve, which if developed would represent an additional asset of $36,000,000. Stretching away from the mill on either side would be 6,300 acres of farm land which the company now possesses along the banks of various rivers to give flowage and other riparian rights.

The principal mill buildings, built of brick, stone and iron, and of the most substantial construction, would cover an area equal to that between Forty-second street and Central Park, New York City, from Fifth to Sixth avenues, in the same city, and surrounding them would be many stores, houses and miscellaneous buildings. Hundreds of dwellings and tenements would be necessary to complete the picture, all belonging to the company.

The power to operate this wonderful mill would be derived from 702 water wheels, ranging from 80 to 1,300 horse power each. In addition to this there would be a steam power plant consisting of a battery of 295 boilers. These boilers consume 443,000 tons of coal per year, and produce steam for driving 196 steam engines, which develop 26,511 horse power. These, however, require not more than fifteen per cent. of the steam developed, the greater part being used for drying the paper. For every pound of paper made two and a half pounds of water must be raised from normal temperature to the point of evaporation, and this would amount to evaporating nearly 4,000 tons of water every twenty-four hours. Steam is also used for cooking the wood in the sulphite digesters, for heating the plants during the winter and for various minor purposes.

Let us return to the point where the wood is brought into the mill, both for making ground wood and sulphite. We see the logs sawed into convenient lengths. The bark is then removed by machines called "barkers," which are rapidly revolving disks having many radial knives. If arranged in a single row, with the customary space between them, these "barkers" would extend 1,700 feet. Just here the preparation of the wood differs, according as it is intended for the ground wood mill or the sulphite mill. If for the former, the wood goes directly to the mill after passing through some minor processes; if for the latter, it is introduced to the "chippers," which consist of revolving knives set at such an angle that they cut the wood into small chips. The chips are then conveyed mechanically to storage bins, ready for the digesters.

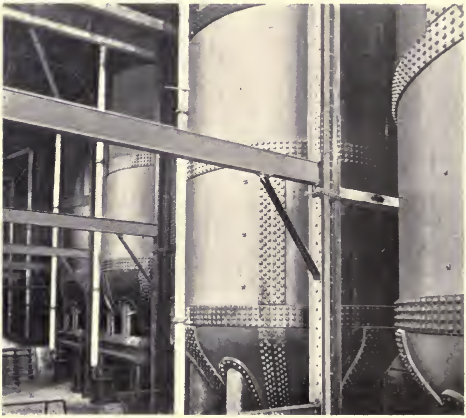
Entering the ground wood pulp mill we see an array of 416 pulp "grinders," attached directly to the shafts of the water wheels, and requiring a room one mile long if arranged one grinder on a shaft. These grinders on an



Grinder and Screen Room
The International Paper Company

average require 300 horse power each, making a total of 124,800 horse power. By these grinders the wood is ground into pulp, which, mixed with water, passes on to the "screens," numbering 765. The screening or straining process is to remove the coarse pieces of wood. After being screened, the pulp, amounting to 1,100 tons every twenty-four hours, either passes to the presses, by which a greater part of the water is extracted; or the liquid pulp is pumped into storage tanks, ready for mixing with the other ingredients of the paper.

A visit to the sulphite mill will be most interesting. In the sulphur storehouse there are frequently stored 4,500 tons of sulphur or brimstone. This sulphur is burned in ovens at the rate of 20,000 tons a year, and the fumes are combined with other chemicals to produce the liquor in which the wood is cooked. The other principal ingredient of the liquor is lime. Of lime about 20,000 tons are used every year. The lime, water and sulphur fumes are mingled and make sulphurous acid, which is

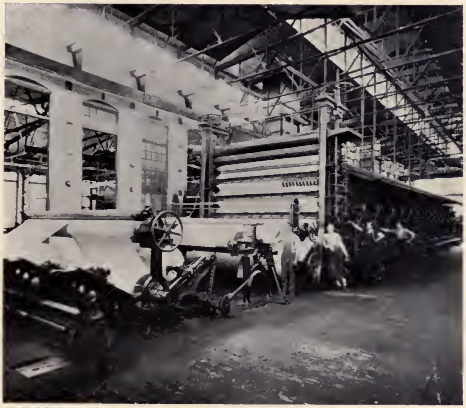


Digesters
The International Paper Company

stored in tanks in readiness for use in the process of cooking the wood. From these tanks the liquor is drawn to the "digesters," which are huge steel boiler-like structures standing on end, and lined in various ways with cement and lead so as to be impervious to acid and to withstand steam pressure. There are fifty-eight of these, ranging in height from twenty-seven to forty-seven feet, with a total cubical contents of 780,000 gallons.

Every nine hours on the average, these digesters are filled with chips and sulphite liquor and the contents are emptied at like intervals, the wood having been reduced to a pulpy state by the process of cooking. This substance is screened and pressed in a manner similar to that used in treating the ground wood. From the presses 415 tons of sulphite pulp are taken off every twenty-four hours.

The next step in the process takes us into the paper



Paper Machine
The International Paper Company

mill, where the ingredients of paper are assembled. In an immense room there are 282 beating engines of an average capacity of 3,200 gallons. In these are mixed the ground wood, sulphite pulp and various chemicals. It requires 100 tons of concentrated coloring matter, 10,500 barrels of rosin and 4,628 tons of alum per year to color and "size" the product of the International Paper Company.

This stock, in a liquid form, finally reaches 111 paper machines, which range in length from 125 to 225 feet, and from which, day and night, is reeled off a total of 1,600 to 1,700 tons of paper in twenty-four hours. These paper machines are massive in construction, but of the finest adjustment. If made into a strip the width of the average daily newspaper, this daily output of the combined mills of this company would form a ribbon long enough to encircle the earth.

As it comes from the machines, the paper is mostly finished or wrapped in the form of rolls, varying in weight from 300 to 1,500 pounds each. Some of the product is cut into sheets and wrapped into bundles. Merely to wrap the paper requires annually more than 8,oco tons of wrappers, which are made by the company.

It is well understood that in supplying the daily papers all over the world, their fluctuating demands should be responded to promptly, and therefore it is necessary to carry in store at the mills, on an average, 15,000 tons of paper in addition to the stock carried at all important points of delivery, which is even a larger quantity. To get to market in one train the total output of paper during one year, which amounts to 450,000 tons, would require 22,500 cars.

It is of this vast and thoroughly organized business that the big paper mill of Niagara Falls is an important factor. When the development of the Niagara Falls Power Company was commenced, the river washed the site where the mill now stands, but in response to the demands of industry the river was crowded back to make room for this plant. The buildings are all of brick, some two stories and some three stories high. Five acres of ground are covered, and to the west of the mill there is a spacious wood yard.

The wheelpit of the mill is 28 feet wide, 56 feet long and 165 feet deep. In it are installed six water-wheels, three of which have an individual capacity of 1,100 horse power, while each of the other three develops 1,300 horse power, making the total power of the mill over 7,000 horse power. The mill has six paper machines, five of which are 120 inches wide, and the sixth 136 inches wide.

The plant is devoted to the manufacture of news paper, the output being 140 tons a day. Of ground wood 65 tons are made daily and a further capacity is projected. There is also a daily output of 42 tons of sulphite.

In addition to the water power referred to, the mill has a steam plant of 2,600 horse power, which is used mainly for drying purposes. It has its own electric light installation in two 600-horse-power electric generators, while for operating its wood conveyors two 30-horse-power motors are used. Possibly there is no more inter-

Press Room
The International Paper Company

esting feature about Niagara and its paper mills than the manner in which this great mill receives its wood supply. The wood is brought down the lakes from Brimley, Mich., on barges, and unloaded in a boom yard on Grand Island, two miles above the mill. The company has a tug and a tow boom, and by this means the wood is brought from the island to the mainland near Schlosser Dock, where it is floated into a boom that runs parallel with the shore, along the lands of the Niagara Falls Power Company, to a point back of the mill, the current carrying it down stream. Near the entrance to the inlet canal it is placed on a log conveyor, which carries it to the company's yard, where distribution is made by means of three lateral conveyors, all operated by electric power. The capacity of the wood yard is about 30,000 cords, which supply carries the mill through the winter months.

ELECTRICAL LEAD REDUCTION COMPANY

A NEW process for the reduction of lead by electricity, under patents of P. G. Salom, has been conducted at Niagara Falls during the past three years by the Electrical Lead Reduction Company.

The chief merits of the invention are the reduced cost of production of pure lead, for all the uses for which it is adapted, and the rapid and economical conversion of the same into its various commercial forms. The process as now conducted is as follows:

The ore, after having been carefully washed, to remove as far as possible the dirt and loose gangue, is ground up into fine powder, of 40 or 50 mesh, and is fed into large circular cells with rotating bottoms. As the bottom slowly revolves, the ore is subjected to a current of electricity, and by the time it has reached the point of entry is thoroughly reduced to metallic spongy lead and is removed from the cell through an opening in the top, from time to time as it accumulates, by a scraper resting on the bottom of the cell.

Each cell has a capacity of 200 pounds of sponge a day. The process is continuous—a uniform quantity of ore being charged per hour. The operation of the cell is entirely automatic. The cells are placed in rows of seventeen or more each, with a motion rod or bar between them, to which is fastened from each cell a lever actuating a pawl and ratchet, with suitable gear wheels, by means of which the cell is rotated at the speed desired—the only manual labor employed at present, being in charging the cells with the raw ore, and in taking out the spongy lead obtained by the process of reduction. The time required for reduction is about one and one-half hours.

The process of charging the ore can readily be accomplished automatically, when a sufficient number of cells are in operation to make it desirable to do so. To operate 100 cells, capable of producing 200 lbs each of lead sponge per day, only three men are required. As the operation, however, is continuous, day and night, two shifts per day are required.

The sponge is readily convertible into any of the lead compounds, such as litharge, red lead, white lead, etc., and in the space of a few hours. The

company's product up to the present time has been litharge, for which it has found a ready market for every pound manufactured. The chief value of the sponge is in the manufacture of white lead and for storage batteries.

The electrical equipment consists of two 300-h.p. Westinghouse Type "C" induction motors, connected direct to two 250-kw. direct current, 110-volt generators. The induction motors take current direct from the 2,200-volt, 2-phase circuits of The Niagara Falls Power Company.

Castner Electrolytic Alkali Company

INTERNATIONAL ACHESON GRAPHITE COMPANY

IN the plant of the International Acheson Graphite Company is found one of the few successful duplications of nature's processes. Graphite and its many important uses have been known for many ages, but it is only during the last few years that it has been produced artificially. The company started commercial work on a small scale in the year 1898 and contracted for 500 h. p. with The Niagara Falls Power Company. This was soon increased to 1,000 h. p., and arrangements are now being made for extensive additions to the plant and for a still further increase to 2,000 h. p. in the power consumed. With this increase several thousand tons of artificial graphite will be manufactured each year.

In 1891, Mr. E. G. Acheson was experimenting on the production of a crystalline form of carbon by heating a mixture of clay and coke in an electric furnace. These experiments resulted in the discovery of a new compound of carbon and silicon, now well known as the celebrated abrasive carborundum. While manufacturing this in the electric furnace, Mr. Acheson frequently found in the latter a form of carbon having all the properties of graphite, and investigation proved that this was formed by the decomposition of the carbide of silicon. It requires a very high temperature to form carbide of silicon, but if the temperature is raised still higher the compound is broken up into its elements, the silicon being driven off as a vapor and the carbon left behind as pure graphite.

Having developed the manufacture of carbide of silicon, Mr. Acheson next took up the problem of the commercial manufacture of graphite from amorphous carbon. The fact that graphite is formed by the decomposition of carbide of silicon suggested that other carbides might also yield graphite when decomposed by raising them to a high temperature. This inference proved to be correct, for Mr. Acheson found that he could produce graphite from a great number of carbides, such as the carbides of aluminum, manganese, iron, etc. But in most carbides the weight of the carbide-forming element is much greater than that of the carbon; for example, carbide of silicon contains 70 per cent. of carbide-forming material, *i. e.,* silicon, therefore from 100 pounds of that carbide there can be produced only thirty pounds of graphite, and sufficient heat energy to vaporize seventy pounds of silicon is required. However, as the investigation progressed it was found that if a relatively small amount of the carbide-forming material was intimately mixed with the amorphous carbon, the latter was converted into graphite, this being explained by the hypothesis of a catalytic or contact action.

The first use for Acheson Graphite was found in the manufacture of electrodes for electrolytic and electro-metallurgical work. These are made up like an ordinary carbon, such as is used in arc lights, but a certain amount of carbide-forming substance is added. When the electrode is heated in the electric furnace the carbide-forming element reacts with the carbon, forming a carbide, and at a still higher temperature is driven off, leaving the electrode in the form of perfectly pure graphite.

Such articles, known as Acheson Graphite Electrodes, are proving invaluable in practically all lines of electrochemical work on account of their purity, high electrical conductivity, uniformity and resistance to oxidizing and disintegrating action. The density is 2.25 and the specific electrical resistance 800×10^{-6} ohm per cubic centimetre as against $4{,}000 \times 10^{-6}$ for the ordinary amorphous carbon. In such processes as the decomposition of sodium chloride solutions in the manufacture of chlorine and caustic soda, they have a life from four to eight times that of even the best retort carbon. A further and distinct advantage not possessed by any other form of carbon material is the ease with which the graphite articles can be machined. Rods and slabs can be assembled into economical anode forms, and in electric furnace work threaded joints can be made between electrodes and these electrodes fed into the furnace one after the other as consumed. The graphite articles are also used in other lines of electrical work, such as for motor and generator brushes, sliding contacts, plungers for dash-pots and circuit-breaker terminals. For this latter purpose they possess peculiar non-arcing properties.

In the Acheson process of making carbide of silicon, the furnace is heated by passing an electric current through a core of granular coke. After the furnace has been operated, many of the grains of coke are found to consist of an excellent grade of graphite; and examination has shown that its formation is dependent on the ash contained in the original coke. The graphite, however, is by no means uniform, as might be expected, as the distribution of the carbide-forming ash is irregular. But the production of this graphite suggested the idea that a highly satisfactory graphite might be obtained if a carbonaceous material containing a suitable, uniformly distributed ash could be found. With this object in view, Mr. Acheson made numerous experiments on various carbonaceous materials, and found that he could produce the most generally useful graphite from anthracite coal. It was also found that petroleum coke yielded a very satisfactory graphite for certain purposes.

The furnaces used for the conversion of anthracite coal into graphite are in the form of long, narrow troughs built of fire brick and lined with some suitable refractory material. At each end of the trough is a terminal built of large carbon rods, to which are connected the cables conveying the current. The trough is filled with anthracite coal, in which is bedded a carbon rod to make electrical connection between the terminals. Anthracite coal is a very poor conductor of electricity, hence the necessity for this rod. A current developing a thousand horse-power is used in

Furnace Room—International Acheson Graphite Compauy operating one of these furnaces, although larger furnaces are now being installed with a capacity of 2,000 h. p. each. The temperature to which the coal is raised before conversion into graphite is very high. Some notion of the temperature may be obtained from the observation of the deposit of silica on the walls of the furnaces. During the operation the silica of the ash carried by the anthracite coal is reduced and the silicon combines with carbon to form silicon carbide; eventually this is decomposed and the silicon is driven to the outside of the furnace in the form of incandescent vapor, which burns in the air, depositing silica as a fine, white powder on the brick walls. In the same way other constituents of the ash, such as iron and aluminum, are vaporized and dissipated.

When the furnace has cooled the graphite is removed, taken to a mill, where it is crushed, and finally separated into the sizes necessary for the various uses to which graphite is put. Thus, graphite used for a pigment is ground to an impalpable powder, while that used for crucibles is in the form of a coarse grain or flake. In the case of natural graphites, when a pure product is desired, recourse must be had to a costly and troublesome process of purification by acids and washing; but since Acheson graphite is produced at a temperature where all bodies but carbon are vaporized, it follows that its purity depends on the length of time for which it has been heated. For commercial purposes it is customary to leave only from one to ten per cent. of impurities in the graphite. It is possible to make it practically chemically pure, for graphite containing only three parts of ash in 10,000 has been obtained; but for ordinary commercial purposes such a high degree of purity is unnecessary, and of course such a pure graphite is more expensive than the lower grades. When the graphite is burnt, all the impurities are found in the residual ash, which consists principally of silicon, iron and aluminum, the first predominating.

One of the most valuable applications of Acheson graphite is found in the manufacture of protective coatings for structural iron and steel, and large quantities are now used for this purpose, for which its qualities of purity, uniformity and chemical inertness make it especially valuable. The only impurities present are silicon carbide—one of the most chemically inert bodies known—and traces of silica, iron oxide and alumina. Since Acheson graphite is made at a temperature at which all but the most stable chemical compounds cease to exist, all decomposable bodies are destroyed. In its use there is absolute control over all three elements entering into the manufacture of a high grade protective coating, viz.: The oil or medium, the pigment and the drier. The drier can be selected to meet the requirements of each particular case, and the degree of drying can be regulated at will. Most natural graphites, or so-called graphite pigments, are either by-products or low grade ores, in both cases too impure for other purposes. They vary considerably in quality, and have to be mixed with lampblack or high grade graphite in order that some semblance of uniformity may be maintained. Acheson graphite is standard and has fully proved its superiority over the natural graphites for the protection of buildings, bridges, cars, vessels, or in fact every form of structural iron and steel.

Acheson graphite is also used in lubricating work and as foundry facings. In the electrical arts it has values peculiar to itself. There is no other form of carbon, either amorphous or graphitic, which possesses in the same degree high electrical conductivity, purity, uniformity and inert characteristics. These properties are all absolutely necessary in the material to be used as the filler in dry batteries. The high conductivity gives a battery of low internal resistance and high current capacity; the purity and inert characteristics give one free from deterioration and local chemical action between the graphite and the solution used as electrolyte; and the uniformity gives one whose efficiency and reliability of action can be guaranteed.

Acheson Graphite is also used for electrotyping purposes and is added to the carbon compounds from which motor brushes are manufactured, not only increasing the electrical conductivity of the brush, but giving self-lubricating properties as well.

Acheson graphite is a manufactured product possessing all the value, with none of the inherent disadvantages, of the natural graphites. Over all stages of its manufacture there is absolute control. By the choice of different forms of raw materials, and by the proper application of the principles involved in its manufacture, different grades can be made to meet the requirements of different lines of work. All grades are pure, uniform and inert, but in other characteristics each grade is made to fulfill most satisfactorily the conditions of the work in which it is to be used.

ROBERTS CHEMICAL COMPANY

THE Roberts Chemical Company manufactures high grade caustic potash and chemically pure muriatic acid. The process is purely electrolytic, and consists in electrolyzing muriate of potash in a diaphragm cell. On the cathode side of the partition liquid potash and hydrogen gas are produced, while the anode side gives off chlorine gas. A considerable quantity of the potash is sold in the liquid form, but most of it is concentrated and then evaporated in kettles to the solid form. In this form it is put up in iron drums. The liquid potash is shipped in carboys or iron tanks.

Muriatic acid is produced by the chemical combination of the hydrogen and chlorine gases. The muriatic acid fumes thus formed are absorbed by distilled water, producing muriatic acid of exceptional purity. The muriate of potash from which these products are manufactured is imported from Germany, and is also used in the manufacture of chloride of potash, fertilizers, and a number of other products.

The use of potash in manufacturing soaps is similar to that of caustic soda, but since it sells at from three to four times the price of caustic soda, it is not used when the latter can be substituted. Caustic soda makes hard soaps; whereas caustic potash makes a soft soap. All the high grade toilet soaps contain a large quantity of potash, and practically all of the soaps used for washing silks and woolens must be made of potash, since soaps made with caustic soda deteriorate the fibre of such fabrics.

Caustic potash is very extensively used by the electro-plating trade for removing grease from the work before it is plated. The soft soap formed with the grease by potash is much more readily dissolved than hard soap would be, with the result that the work is cleaned much more quickly and much more thoroughly than if caustic soda was used.

Muriatic acid is largely used by chemical laboratories and by manufacturing chemists in the production of a number of other chemicals.

THE FRANCIS HOOK AND EYE AND FASTENER COMPANY

THE Francis Hook and Eye and Fastener Company, located upon the lands of The Niagara Falls Power Company, manufactures snap fasteners of an improved type for use on gloves, purses, umbrellas, optical goods, ladies' garments, and on the many other articles to which snap buttons are applicable. These fasteners are patented. The machinery and processes used in their production are of such a nature as to require much skill and care in handling.

The Francis machines were constructed to a large extent in the machine shop of the company, where new machines are constantly being built and old ones improved.

Francis Hook and Eye and Fastener Company

All the machinery is operated by electric power, derived from 550-volt direct current motors.

The Francis plant is of the most approved factory construction, having been built especially for the purposes of the company after years of experience in a smaller building.

NORTON EMERY WHEEL COMPANY

THE Niagara Falls Works of the Norton Emery Wheel Company are devoted exclusively to the manufacture of the abrasive, "alundum." This abrasive is manufactured by a patented, electrical-furnace process and is shipped to the main works of the company at Worcester, Massachusetts, where it is prepared for grinding wheels, stones, grains, and other abrasive articles.

This electrical-furnace plant was started in 1901, being located at Niagara Falls to secure the advantage of electric power. The factory has been enlarged several times and additional furnaces and other apparatus have been installed.

Alundum is an electrically produced crystalline oxide of aluminum. In nature the crystalline oxide of aluminum occurs in its purer forms as the ruby and sapphire, and in its more common form as corundum. Corundum is the hardest natural product known except the diamond, but is not as hard as alundum.

The superiority of alundum in hardness and toughness is accounted for in the process of manufacture by the peculiar conditions of its crystallization in the electric furnace, and by the control of its purity and uniformity. This electrically produced corundum, while it resembles natural corundum in many respects, is much superior in hardness and toughness.

Bauxite, the raw material from which alundum is made, is an amorphous hydrate of aluminum, associated with certain impurities which are removed in the process of manufacturing alundum. Bauxite was originally found at Baux, France, from which it derives its name, but purer forms are now found in Georgia and Arkansas.

This hydrate is reduced to an oxide, melted in electric furnaces of special design, the impurities removed, and large pigs of solid alundum produced of most beautiful coloring and crystalline structure.

The process of transforming bauxite into a pure, crystalline abrasive, was invented by Charles B.

Norton Emery Wheel Company

Jacobs, of New York City, and is protected by United States and foreign patents, which are controlled exclusively by the Norton Emery Wheel Company.

Six large electric furnaces are installed, together with other apparatus for carrying out the process.

A large crushing and grading mill for crushing and grading alundum is located at Worcester, Mass., where it is manufactured into abrasive wheels, stones and other articles. Alundum is also used to a large extent on abrasive paper, for grinding glass and for polishing, in all of which lines it has marked advantages.

The Natural Food Company

THE NATURAL FOOD COMPANY

THE Natural Food Company manufactures the products known as Shredded Wheat Biscuit and Triscuit. In the manufacture of "Triscuit," the first commercial use of electricity for baking has been made.

The factory of The Natural Food Company is situated on Buffalo avenue, between Fourth and Sixth streets, occupying an entire block. This location is in the heart of the residence section of the city. It has a frontage of 900 feet on the Niagara River and adjoins the State Reservation, so that other manufacturing industries cannot encroach upon the plant. The absolute cleanliness in surroundings, required in the process of the manufacture of a pure food, is thus secured. The building is 466 feet long by 66 feet deep, and consists of a main building with four connecting wings.

Upon entering the building one steps directly into a large foyer or reception hall, where guides are at hand for the purpose of conducting parties through the plant. Just off the foyer are two electric elevators used for conveying visitors to the roof garden, or observatory, from which a magnificent view of the upper rapids and of the industrial section of the city may be obtained.

The first process of the manufacture is seen in the cleaning room. This process is that of cleaning the wheat as it is received from the fields, and consists of twenty-six steps, by means of which fourteen foreign substances are removed from the grain, which is thus rendered thoroughly clean and ready for the cooking and shredding processes.

From the cleaning room the visitor is conducted to the gallery of the girls' dining room, where a substantial luncheon is provided daily, at the expense of the company, for the girls in its employ.

From the dining room, one enters the sealing room, in which is conducted the last step in the process of manufacture. The sealing is done by a

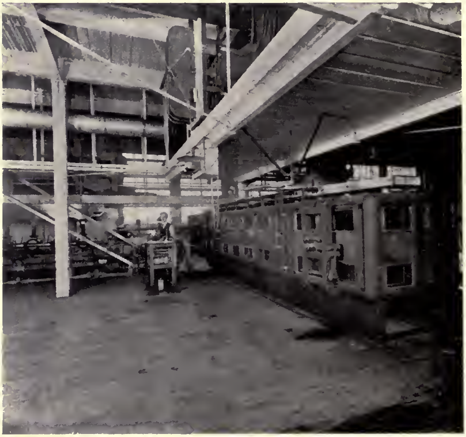
Views in the Factory – The Natural Food Company very ingenious machine, which receives the packages conveyed automatically from the packing tables on the second floor, and which closes and in turn seals each individual package. After this operation the packages are placed in cases containing twenty-five or fifty cartons each, and are then ready for shipment.

The visitor is next brought to the auditorium, which has a seating capacity of 1,080, and is used for concerts, lectures and other entertainments. The use of this hall is given free to any convention desiring to hold its sessions at Niagara. The hall is well equipped and has adjoining toilet rooms and committee rooms.

From the auditorium one passes to the third floor of the building, where the wheat is exposed in large open trays undergoing the "curing process," which consists merely of drying the wheat to bring it to the proper consistency for shredding. This is the third step in the process of manufacture, the wheat having been previously "cooked" for thirty-five minutes by steaming in revolving wire kettles located upon the sixth floor. After the wheat has reached the proper consistency, it is "spouted" to the shredding floor directly beneath.

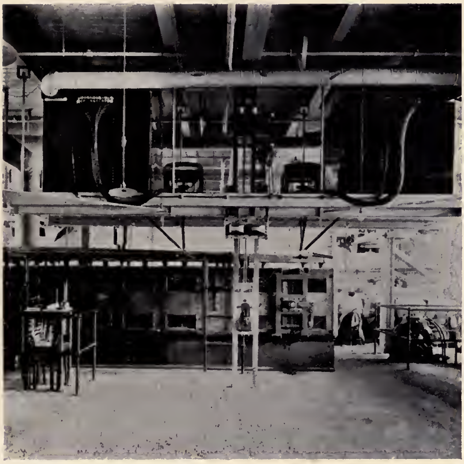
Adjoining the curing room is the space devoted to the manufacture of "Triscuit," which is made and baked by electricity. Its manufacture is identical with that of Shredded Wheat Biscuit, with the exception of the baking. The wheat is spun into shreds by mechanical process and is conveyed by an endless belt to ovens, each consisting of a series of electric stoves, each link of which is somewhat similar to an ordinary waffle iron, and contains 127 electrical points. The shreds are deposited automatically upon the series of links, which are met from above by another series of links which, pressing upon the product, forms and bakes the wafer known as "Triscuit." Three hundred and fifty horse-power is used in the operation of each of the electrical ovens. The triscuit are automatically deposited on carriers and taken to the packing tables, where, for the only time, they are touched by hand, when they are placed in cartons by neatly attired girls.

From the triscuit room one descends to the second floor, where the Shredded Wheat Biscuit are prepared. The wheat "spouted" from the curing room is distributed automatically to a series of thirty-six pairs of rolls, technically known as "shred-



Electric Triscuit Oven
The Natural Food Company

ders." The shredder consists of a corrugated roll four inches wide, with twenty corrugations to the inch. This corrugated roll "antagonizes" a smooth roll, and the wheat being pressed between is spun into shreds and deposited on an endless belt directly beneath it. Each shredder in turn deposits a layer of shreds upon this belt, until the proper thickness is reached. From the shredding machine the shreds pass to the cutter, which automatically cuts the shreds into biscuit shape, and places them on a wire pan for baking. The pans are placed in racks and carried to a large Ferris wheel oven, where for thirty minutes they revolve slowly over a bed of coals in a temperature of about 450° F. The biscuit are thus thoroughly baked, but to expel any moisture which may be yet present in them they go through a second baking in a drying oven, consisting of a low



Transformers and End of Electric Triscuit Oven
The Natural Food Company

horizontal structure, approximately 150 feet in length, through which the pans are carried automatically. In this oven the biscuit are exposed to a temperature of from 200° to 300° F. for a period of nearly one and one-half hours. As the biscuit come from this second oven they are thoroughly dry and crisp and are ready for the market.

From the second oven the biscuit go to the packing tables, where, for the first time in the process, they are touched by hand, when the girls pack them in cartons holding one dozen each. From the packing table the cartons are conveyed automatically to the sixth floor, where they enter the sealing machine previously described.

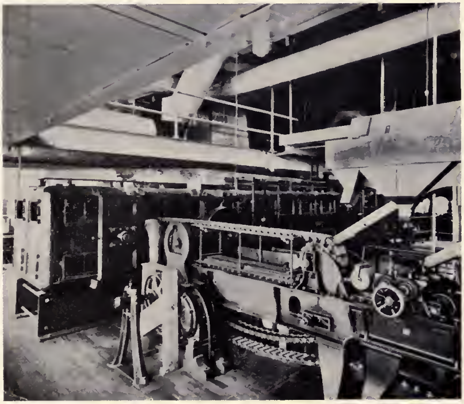
The visitor is next taken to the basement floor, where are located paint shop, mill-wright and carpenter shops and electrical rooms, as well as bicycle racks. Here, also, is located the ventilating system, which changes automatically every fifteen minutes the air in the manufacturing section. In the offices the air is changed every seven and one-half minutes, and in the lecture hall every five minutes.

Each floor is provided with two lavatories, finished in marble and mosaic, and equipped with shower and needle baths supplied with hot and cold water. The employees are allowed ample time for the use of the baths and are furnished with soap and towels by the company. Individual lockers are also provided for the employees.

In the work conducted by the Natural Food Company there has been no attempt to work out any sociological problems, or to carry on experiments of any kind. The thought which has actuated the company has been merely to surround the employees with ideal working conditions.

In the manufacture of Shredded Wheat Biscuit and Triscuit nothing is used but the whole of the wheat, the grain being merely cleaned, steamed, shredded and twice baked. Nothing is added to and nothing is taken away from the perfect wheat.

In the operation of the factory and for its lighting, 2-phase, 25-cycle alternating current, supplied by The Niagara Falls Power Company, at a potential of 2,200 volts, is used. After leaving the terminal board, located in the east Transformer Room, the current passes through automatic oil circuit breakers. There are three of these circuit breakers, two of which control the lines supplying the east and west Transformer Rooms, while the third handles the lines supplying the transformers located in the Triscuit Department on the third floor of the factory. In each Transformer Room are located four Westinghouse oil-insulated self-cooling transformers. Two of these transformers, of 75 kw. each, furnish half the factory with a 115-volt lighting current. The two remaining transformers furnish their half of the factory with a 440-volt current for oper-



Triscuit Cutter and Panner
The Natural Food Company

ating the motors. In the east Transformer Room is located a 150-kw. rotary converter, supplying a 220-volt direct current for operating the elevators in both the Administration Building and the Factory. The west Transformer Room is a duplicate of the east Transformer Room, with the exception that it contains a 12-kw. motor generator set instead of a rotary converter. This generator is used in charging storage batteries which in turn operate the bells and the telephone system. The factory is operated by

87 induction motors, ranging in size from one h.p. to 40 h.p., and the buildings are lighted by 2,500 incandescent lamps.

On the third floor of the factory are located eight 140-kw. transformers, supplying the four triscuit ovens with current for baking. By means of a voltage regulator the voltage on the secondaries may be varied from 80 volts to 127 volts. Each set of transformers is supplied by an automatic oil circuit breaker.

RAMAPO IRON WORKS

THE Niagara Falls plant of the Ramapo Iron Works of Hillburn, Rockland County, N. Y., is situated at the corner of Buffalo avenue and Iroquois street.

In 1903, the Ramapo Iron Works took over the interests and building of the MacPherson Switch and Frog Company, a company engaged in manufacturing switches, frogs and other railway supplies. Since this combination was formed, the Ramapo Iron Works has added to its Niagara plant several new buildings, including a switch shop 293 feet long by 85 feet wide, and a crossing shop 285 feet long by 75 feet wide. The output of the old MacPherson Switch and Frog Company has thus been multiplied threefold. The buildings are of brick and wood, with iron sheathing covering the wood. The sides of the buildings are mainly of glass, making a very light and healthful plant for the men to work in.

The machines are all driven by electric power obtained from The Niagara Falls Power Company, no steam or other power being used. The electrical equipment consists of step-down transformers having ratios of 2,200 volts to 440 volts and to 110 volts, with an aggregate output of 450 kw. Current is supplied through these transformers to 440-volt, 2-phase motors, scattered about the works, and to incandescent lights operating on 110-volt circuits.

The company is now constructing a building to be used as a restaurant for the employees, in which hot meals will be served at noon.

THE COMPOSITE BOARD COMPANY

COMPOSITE board is the result of numerous experiments to produce a material having the desirable qualities of ordinary lumber without the objectionable features of natural wood. The patentees of the process have succeeded in producing from wood pulp and flax fibre, a chemically treated board or panel, which having no grain like ordinary wood will neither split nor check, and which may be made in sheets or boards of any desired thickness by glueing, under great pressure, the separate layers. The material is produced in panels, 7 feet by 14 feet, thus obviating the necessity of joints or seams where large surfaces are to be covered. In the process of manufacture it may be curved to any given radius. Efforts to fireproof the material have been successful, and board is now produced which is not only flame resisting, but which has excellent qualities as an insulator of electricity. Tests have proved that a quarter-inch sheet of composite board required 28,000 volts alternating for its puncture, while a half-inch sheet withstood successfully 47,000 volts alternating.

Composite board is used extensively for interior finish of railway coaches and in marine work.

The plant of the company consists of large brick buildings on the lands of The Niagara Falls Power Company. Power is received from the circuits of that Company at 2,200 volts, 2-phase, and is stepped down to 220 volts for use in induction motors, by means of which the various machines in the plant are driven. Upwards of 200 h. p. in all are used.

NIAGARA RESEARCH LABORATORIES

THE maintenance of universities and, especially, of technical institutions, is generally recognized as an efficient means of promoting the development of science and of enabling the greatest industrial benefits to be derived from the results of scientific progress.

The rapidly increasing importance attached to applied science in the courses of instruction in the

Niagara Research Laboratories

scientific schools has necessitated a corresponding enlargement of laboratory equipments; so that today, many of these institutions offer excellent facilities for a thorough education, and for scientific research. Although many industrial processes have originated and have been investigated in the university laboratory, most of these have required further development before commercial success was attained, because of the limited scale upon which experimental work is usually conducted in such laboratories. The unexpected technical difficulties frequently encountered when these processes are operated on a manufacturing basis, and not previously met with in the work on a small scale, have in many cases, been the cause of unfortunate results.

Realizing that the establishment of a plant equipped with facilities for chemical, electrochemical, and electro-metallurgical investigations and developments on a commercial scale, would offer peculiar advantages to inventors and manufacturers, fulfill an obvious need, and enable the experimental and consulting engineers of the company to develop their original ideas, the Niagara Research Laboratories were organized, and erected the building shown in the accompanying illustration, on the lands of The Niagara Falls Power Company.

Situated on the ground floor of the building are the machine shop, grinding room, transformer and dynamo room, electric furnace laboratory, and the isolated spaces available for experimenters wishing to conduct work of a private nature. On the second floor are the chemical and electrochemical laboratories, and offices of the company. The top story is used for photographic work, for investigations of the chemical effects of the various light rays, and for storage purposes.

Electrical energy is received from The Niagara Falls Power Company, in the form of a two-phase alternating current, at 2,200 volts, constant potential. By means of various transforming devices and motors located in the power room, this energy is utilized in the operation of electric furnaces and electrolytic cells, the machine shop and grinding room, and in the heating and lighting of the building.

The alternating current transformer used in connection with high temperature experimental work is of the water cooled, oil insulated type, and has its windings so constructed that the full capacity of the apparatus, 500 e. h. p., may be obtained at variable secondary voltages.

Interior Views
Niagara Research Laboratories

Direct current of sufficient volume to permit of the electrolysis of compounds in the fused condition is derived from a low potential generator of the double commutator type. According to the arrangement of the external connections of this separately excited dynamo, which commutates perfectly its full load current under wide variations of field strength, either a current of 2,000 amperes at any electromotive force, not exceeding eight volts, or a current of 1,000 amperes at any pressure not exceeding sixteen volts may be obtained.

Separate sets of bus bars carry the current from the generator and transformer to the electric furnaces, and are so arranged that connections can be readily made to apparatus erected in any part of the furnace room.

Various types and sizes of electric furnaces are in use. Some of these are suitable for a general class of work and are frequently employed in the early stages of an investigation; other furnaces have been constructed to meet the requirements of special problems and utilize 500 e.h.p. in their operation. The electrical instruments employed in the furnace room are mounted on a portable switchboard and their design is such that accurate scale readings may be obtained from zero to 10,000 amperes. Integrating wattmeters are also used in connection with the electric furnace circuits, thus enabling, in the case of alternating currents, the determination of the power factor of such circuits, a matter that has not received too great attention.

The analytical laboratory is equipped in a modern way for the analysis of such organic and inorganic compounds as may be met with in experimental work, and with facilities for general chemical research. Many convenient electrical heating appliances are in use in this laboratory.

The equipment of the electrolytic laboratory consists of the electrical measuring instruments, resistances, storage batteries, rectifiers, and other apparatus necessary for the simultaneous conduct of several electrochemical investigations.

Ore crushing and pulverizing machines of a standard type are installed in the grinding room, and the machine shop tools are also of a standard type. They are necessary adjuncts, however, to an experimental laboratory of this class.

It may be understood from the above description that the object of this company was not only to establish a laboratory in which scientific research could be conducted, but to provide facilities for the development and demonstration of electrochemical processes on a sufficiently large scale to determine the prospects of their commercial success.

Canadian Tenants of the Niagara Falls Power Company

THE first demands for Niagara power in Canada, aside from that used for railway purposes, were met by the Canadian Niagara Power Company by the installation in the Power House of the International Railway Company, in Queen Victoria Niagara Falls Park, of two 500-h.p., 2,200-volt, 3-phase alternators, driven by turbines. Subsequently this installation was reinforced by the laying of a 2,200-volt, 3-conductor cable from the Power House of The Niagara Falls Power Company on the American side to the railway Power House in Canada, the carrying capacity of this line being approximately 1,000 h.p. The distribution to the various users of power is made by means of overhead 3-phase 2,200-volt transmission circuits.

To meet the increased demands for power, and in anticipation of the abandonment of the alternator plant in the Railway Company's Power House, an 11,000-volt, 3-conductor cable was installed between the American Power House and the railway plant in Canada, and step-down transformers having a ratio of 11,000 to 2,200 volts were placed at the Canadian end of this cable. On account of the reconstruction of the Railway Power House, the two alternators were removed in July, 1903, since which time all Niagara power used in Canada for other than railway purposes has been transmitted from the American side by means of the 11,000-volt, 3-conductor cable. The 2,200-volt line will be eventually transformed into an 11,000-volt circuit.

The principal Canadian power users are as follows: The Niagara Electric Light Company, using about 400 h.p., mainly in induction motors driving arc machines and alternators; The Toronto and St. Catharines Railway, using 400 h.p.; Ontario Silver Company, 100 h.p.; The Carborundum Company, 300 h.p.; Monastery of Mount Carmel, 100 h.p.

Since the large power developments have been started on the Canadian side, contractors on the three plants have been taking from The Niagara Falls Power Company and the Canadian Niagara Power Company approximately, 1,000 h.p., most of which is utilized by means of induction motors for the driving of air compressors which supply the drills, and other appliances used in excavation. Power is also used for lighting, for traveling cranes and for machine shops. The amounts used by each contractor are as follows:

By A. C. Douglass, in excavating the tunnels of the Canadian Niagara Power Company and of the Toronto & Niagara Power development, 400 h.p.; by the Jenckes Machine Company in the construction of the steel pipe line for the Ontario Power Company's development, 200 h.p.; by M. P. Davis in excavation of wheelpit for the Toronto & Niagara Power Company, 400 h.p.

Long-distance Tenants of the Niagara Falls Power Company

THE CATARACT POWER & CONDUIT COMPANY

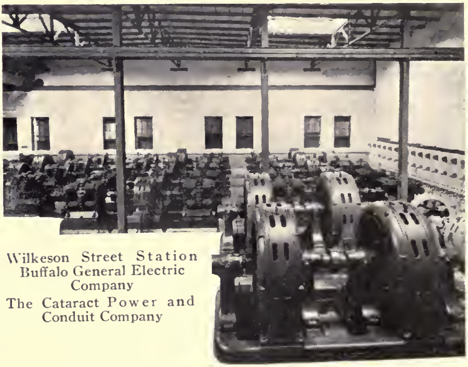
THE Cataract Power & Conduit Company is the distributor, within the city of Buffalo, of power generated by the Niagara Falls Power Company.

The three tri-phase transmission lines from Niagara are carried into a transforming station known as the Terminal House, located at the foot of Ontario street on lands abutting on the Erie Canal. The power is received at the line pressure of 22,000 volts and all Niagara power used in Buffalo is there transformed in pressure from 22,000 volts to 11,000 volts.

The transmission lines enter the building from different routes, two of the circuits carried by No. 1 pole line following the Erie Canal from Tonawanda, while the third circuit carried by No. 2 pole line parallels the N. Y. C. & H. R. R. R. from Tonawanda to Ontario street, Buffalo, and thence follows Ontario street to the station.

Entering the building, each conductor passes through a heavy porcelain tube inserted in a pine board one inch thick. The tube, twelve inches in length, is inclined at an angle of about thirty degrees with the horizontal, the lowest point being outside the building. A metallic awning extends over the lines outside the building and serves as a protection against rain and snow. Inside the building, the circuits consist of rubber-covered, single-conductor cables supported on Niagara type insulators attached to seasoned and well oiled Georgia pine. There is a 22,000-volt switchboard in each end of the building—three panels at one end and two at the other. These switchboards are equipped with non-automatic circuit breakers, some being of the swinging arm air break form, while others are of the oil type. The latter are operated electrically by means of auxiliary controlling switches located at a distance.

As stated above, all power used in Buffalo is transformed in pressure at this station. For this purpose there are in use nine 2,250-kw. oil-insulated, water-cooled step-down transformers having a transforma-



Wilkeson Street Station
Buffalo General Electric Company
The Cataract Power and Conduit Company

tion ratio of two to one. These transformers are connected in delta in banks of three each. Their secondary leads pass to a double set of bus-bars forming part of an 11,000-volt switchboard consisting of eleven panels. Mounted on each of these panels are indicating and integrating wattmeters; two oil type feeder switches by means of which connection can be made to either set of bus-bars; and controlling switches and signal lights connected with the automatic oil type circuit breakers, which are placed above the switchboard structure.

The 11,000-volt current is carried under ground from the Terminal House to three substations of The Cataract Power & Conduit Company and to five substations belonging to the International Railway Company. The Terminal House itself also serves as one substation.

At the Terminal House are installed nine 250-kw. air-blast transformers, receiving 11,000-volt current and transforming it to a pressure of 2,200 volts, at which

Transformer Room, Wilkeson Street Substation
The Cataract Power and Conduit Company

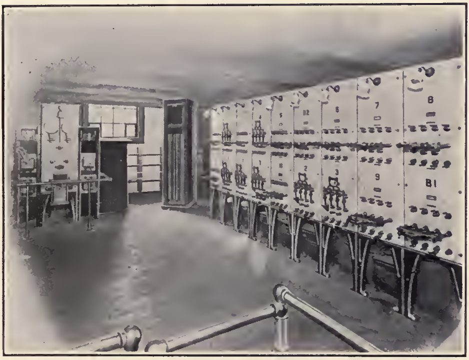
pressure it is carried overhead to consumers, consisting mainly of manufacturers located in North Buffalo. Seven feeder panels are used for the control of the 2,200-volt distributing circuits. These panels are equipped with integrating wattmeters, a double set of bus-bars and oil switches, and also with automatic overload and reverse current circuit breakers. The transformers are connected in delta. The air blast is supplied by a blower connected direct to an induction motor.

Of the other substations owned and operated by The Cataract Power & Conduit Company, No. 2 is located at Ohio street and Love alley, No. 3 is located at Wilkeson street and No. 4 at Babcock and Hanna streets. These three substations receive current from the underground circuits at 11,000 volts and transform it to 2,200 volts. In general, the secondary distribution is by means of overhead conductors, but in a few cases, by means of underground cables.

Substations No. 2 and No. 4 are purely step-down stations, the former being equipped with oil-insulated, water-cooled transformers, and the latter with air-blast transformers. They supply manufacturing establishments in their respective districts.

Induction Motor
The Cataract Power and Conduit Company

Substation No. 3 is equipped with air-blast transformers. Its principal load is that of the Buffalo General Electric Company, whose plant is located in the same building. Current is delivered to the Buffalo General Electric Company in the form of 352-volt, 3-phase, 25-cycle current and is transformed to 550-volt direct current for power purposes; to 60-cycle, 2,400-volt, 2-phase current for commercial incandescent lighting; to 220-volt direct current for an Edison 3-wire system operated in connection with a 6,000-ampere storage battery; and to direct current for series arc street lighting circuits. For the transformation to 550-volt direct current, rotary converters are used. For the frequency changers and for the Edison system, motor generator sets are utilized, while for the arc lighting service synchronous motors connected direct to Brush arc machines are employed. These arc machines deliver a current of 6.8 amperes and each is capable of supplying 125 arc lights in series. The frequency changers are driven by synchronous motors, while the charging sets for the Edison 3-wire circuits are driven by induction motors, the largest being rated at 1,200 h.p. In addition to the power used by the Buffalo General Electric Company, this substation supplies power to a large hotel and to two department stores and to other miscellaneous users. The 25-cycle current is used in many cases directly for incandescent lighting, the excellent speed regulation and the uniform



Switchboard Room at the Great Northern Elevator
The Cataract Power and Conduit Company

angular velocity of the generators at the Falls making this current entirely satisfactory for lighting purposes.

To the substations of the International Railway Company current is delivered at 11,000 volts from underground circuits consisting of triple-conductor, paper-insulated, lead-covered cables laid in tile conduits. The equipments of the various stations are similar, each consisting of air-blast transformers and converters, by means of which the 11,000-volt, 3-phase current is transformed into 550 to 600-volt direct current. From May 1st to October 1st, the International Railway Company operates its entire system by Niagara power. During the winter months an auxiliary steam plant is operated to take care of the peak loads.

Niagara power supplied through The Cataract Power & Conduit Company has been applied in Buffalo to varied uses in establishments of many kinds, among which may be mentioned the following: Grain elevators, cereal mills, foundries, machine shops, malt houses, tanneries, electrolytic and chemical manufactories, ship yards, dry docks, packing houses, metal stamping works, structural steel works, manufactories of jewelers' supplies, car wheel factories, weaving and belting factories, rubber re-claiming works, steel and malleable iron foundries, breweries, bakeries, silk-throwing establishments, flouring mills, railroad shops, box factories, department stores, hotels, central station and isolated lighting plants, street railway power houses, and manufactories of steam and hot water radiators, brass and iron beds, dental supplies, linseed oil, gasoline engines, varnish, cordage, head-lights, refrigerators, refrigerating machines, automobiles, rubber goods, cast iron pipe and fertilizers.

INTERNATIONAL RAILWAY COMPANY

THE system of the International Railway Company presents many features which are of great interest to engineers. Operating over 360 miles of track, its cars traverse all the principal streets of Niagara Falls and Buffalo, and serve all the important neighboring towns.

Crossing the company's beautiful steel arch bridge, just below the falls of Niagara, the tourist is carried eight miles northward to the historic town of Queenston, or three miles southward to the ancient village of Chippewa. Both these places can be visited conveniently on a single trip without changing cars. The scenery between them is beautiful and unique, and possesses much historic interest.

In going from Niagara Falls to Buffalo, a distance of twenty-three miles, the cars pass along the Niagara River

Virginia Street Substation, Buffalo—The International Railway Company through the village of La Salle and the cities of Tonawanda and North Tonawanda. At the latter point connection is made with the line to the city of Lockport, the town of Olcott, and the villages of Charlottville, Burt and Newfane. Lockport is thirteen miles and Olcott twenty-six miles from the North Tonawanda Junction, which is situated about midway between Niagara Falls and Buffalo. Running east from Buffalo are lines to the towns of Lancaster and Depew, eleven miles distant.

On its interurban routes the company has provided elegant, roomy cars with comfortable steam-coach seats and broad windows. These cars are operated by the

Passenger Train on the Buffalo-Niagara Falls Division
The International Railway Company

multiple-unit system of control, either singly or in trains as the service may demand.

The motive power used on the system is entirely electrical and is derived from the hydraulic power of Niagara Falls, and from an auxiliary steam plant in Buffalo. Storage batteries are used to carry peak loads. During a portion of the year the operation is entirely by power taken from the Falls.

The power used locally in the Niagara Falls district is taken partly from the Railway Company's hydraulic plant near Table Rock, on the Canadian bank of the river, and partly from its rotary converter plant in Power House No. 1 of the Niagara Falls Power Company.

The hydraulic plant receives its water in a fore-bay just above the Horseshoe Falls, and discharges through a tunnel 600 feet in length, having its outlet at the face of the cliff close beside the Falls. The effective head of water is 62 feet. The plant contains two 1,000 h.p. 45-inch vertical turbines of the Globe type, bevel-geared to line shafting, from which are belted five 200-kw. railway generators and one 200-kw. feeder booster. There is also in process of installation one 2,000 h.p. 175 r. p. m.

View in Victoria Park, Niagara Falls, Ontario
The International Railway Company

turbine of the single Francis type. This turbine is direct-connected to a 1,500-kw. double commutator, vertical shaft, General Electric railway generator. The power house is arranged to accommodate three more of the 1,500-kw. generators when conditions may require them.

The plant in the Niagara Falls Power House No. 1 consists of three 400-kw. quarter-phase, 25-cycle, rotary converters.

At Paynes avenue, North Tonawanda, where the Buffalo & Niagara Falls and the Buffalo & Lockport lines cross, is located one of the new modern substations.

This station receives 3-phase 22,000 volt, 25-cycle current from the Niagara Falls Power Company's transmission line. The station equipment consists of three 400-kw. General Electric 3-phase rotary converters. The a. c. current for each rotary is stepped down from 22,000 volts to 375 volts by a bank of three 150-kw. air-blast transformers. The rotaries are started by means of double-throw switches connected on one side to half voltage taps and on the other side to full voltage terminals

Electric Locomotive
The International Railway Company

on the secondaries of the transformers. This method of starting obviates the loss of time and the uncertainties of synchronizing.

This station contains a 288-cell 1,000 h.p. (one hour rate) storage battery with motor generator booster for control. There are also high tension and direct current lightning arresters, reactive coils, blower sets for cooling transformers and ventilating battery room, air compressor for cleaning machinery and complete modern a. c. and d. c. switchboards.

A feature of the station is the absolute safety in the arrangement of 22,000-volt bus bars and other high pressure devices. The bus bars are installed in separate brick and concrete compartments, where it would be unlikely for a person accidentally to come in contact with them, and where short-circuits would be quite impossible. The current on the incoming and outgoing 22,000-volt lines and also on the primaries of the transformers, is controlled by means of automatic oil-switches. The switches are of the remote control type, so that at the switchboard panels, where the operator is engaged, there

Fruit and Produce Train on Lockport Division
The International Railway Company

is nothing but low pressure current to be handled. The current for operating the oil-switch motors is taken from a 125-volt storage battery.

The high pressure current for the Lockport and Olcott substations passes through switches in this station, and the power used by all three stations is measured at this point by graphic recording wattmeters.

The Lockport and Olcott substations are fed by the railway company's 22,000-volt transmission line.

The Lockport station contains the same number, type and capacity of machines and batteries as the Tonawanda station, with some modifications of arrangement.

The Olcott substation contains two 400-kw. rotaries, with the necessary auxiliaries, and a 90-kw. 1,040-volt single-phase alternator for lighting the Park and hotel property. The alternator is belted to the shaft of one of the rotaries.

A feature of the Tonawanda-Lockport-Olcott system is the freight service. Two 40-ton electric locomotives are constantly employed in the transferring of freight for the steam roads and in hauling between towns. A large part of the traffic is in fruit from the luxuriant orchards on the shores of Lake Ontario.

The steam-plant of the Railway Company is situated at Niagara and School streets, in the City of Buffalo, on

Upper Steel Arch Bridge at Night
The International Railway Company

the line of the Buffalo and Niagara Falls road. It contains two modern Corliss engines of the Allis-Chalmers make, driving 1,500-kw. 11,000-volt, 25-cycle alternators of General Electric Company revolving field type. There are also three 800-kw. d. c. railway generators, direct connected to upright Lake Erie engines, and a 286-cell 1,800 h.p (one hour rating) storage battery.

Part of the power house is occupied by a rotary converter plant, consisting of four 400-kw. 25-cycle rotaries.

This station is fully equipped with modern switching devices, embracing 11,000 volt bus bars individually isolated in brick and concrete compartments, automatic motor-driven oil-switches with remote control, and latest type of alternating and direct current switchboards.

That part of the alternating current switchboard which accommodates the hand-operated control switches, rheostats, indicator lamps, etc., is assembled in the form of a benchboard. The indicating and recording instruments are situated on panels several feet above this benchboard, allowing the attendant to look out over the station between the instrument and controlling panels.

The Niagara power used in the City of Buffalo is taken in the form of 11,000-volt, 25-cycle, 3-phase current, from the Cataract Power and Conduit Company's terminal house located in the northern part of the city. This current is delivered to the various substations by means of underground lead-covered 11,000-volt cable. The Cataract Power & Conduit Company is the local retailer of Niagara Falls Power Company power, and receives the Niagara power from the 22,000-volt overhead transmission lines.

The Railway Company's substations are located at Seneca and Elk streets, at Walden avenue and Belt Line, and at Virginia and Washington streets, the last named being the largest, newest and most interesting. This station is located approximately at the load centre of the city system, and, in addition to its equipment of four 1,000-kw. 6-phase rotary converters, has two 288-cell 1,500 h.p (on one hour rating) storage batteries.

Each rotary converter receives its current directly from the secondaries of one 3-phase air-cooled transformer. The starting of the rotaries is accomplished by the use of switches connected to one-third, two-third and full-voltage taps on the secondaries of the transformers. Reactive coils are in circuit with the rotaries, and the machines are equipped with speed limiting and mechanical end-play devices.

The alternating current for this station is received over 11,000 volt, paper-insulated, lead-covered cables leading from the steam plant. Both Niagara Falls power and steam-generated power are used.

The high pressure bus bars, as in the steam plant, are carefully isolated in masonry compartments, located in the capacious air pit under the air-blast transformers and oil-switches. All oil-switches can be separated completely from the bus bars for repairs by means of knife blade type "disconnecting switches."

The new Entz system of regulation is here used with the storage batteries. The fluctuations of station load are reduced by this below ten per cent.

This station is arranged to receive three more of the 1,000-kw. rotaries and one more storage battery. As the batteries, when fully charged, are good for 1,300 kw. each, and the rotaries are capable of fifty per cent. overload, the station has an ultimate capacity of 14,400 kw. for an hour, which is the usual duration of the highest peaks.

The other substations, as well as the steam plant, have ample arrangement for accommodation of additional machinery to take care of increased traffic.

The power houses and substations of the International Railway Company are open to visiting engineers who may be interested in making an inspection of them.

TONAWANDA POWER COMPANY

THE Tonawanda Power Company bears to the cities of Tonawanda and North Tonawanda the same relation that the Cataract Power and Conduit Company does to the City of Buffalo, namely, that of local distributor of power generated and transmitted by The Niagara Falls Power Company.

About 2,200 h. p. is delivered to the Tonawanda Power Company, which is used for street arc lighting, commercial and residence incandescent lighting, and for varied industrial enterprises, among which may be mentioned paper mills, nut and bolt works, flouring mills, machine shops, and the manufacture of abrasives.

The station is located in North Tonawanda on Robinson street at its junction with the right of way for The Niagara Falls Power Company's 22,000-volt transmission lines.

The transformer installation consists of two banks of step-down transformers, aggregating 3,000 kw. in capacity, from which secondary voltages of 360 volts, or of 4,400 volts may be obtained. These transformers are connected in delta. The lighting apparatus consists of induction motors driving 60-cycle, 2,300-volt, 2-phase alternators, and of three constant current transformers for the operation of the series arc system used for street lighting. For general power distribution, 4,400-volt current direct from the transformers is used. All of the local distribution is by means of overhead circuits.

Adjoining the plant of the Tonawanda Power Company is the section-house of The Niagara Falls Power Company, through which are carried the three tri-phase transmission lines. In this section-house are installed sectionalizing switches arranged in such a way in combination with bus-bars that either of the three transmission lines may be cut at this point, and so that any desired combination of lines or sections of lines in parallel may be effected. Arrangements are also provided for transferring the load of the Tonawanda Power Company and of the Lockport transmission line to any of the three main transmission lines.

THE LOCKPORT GAS AND ELECTRIC LIGHT COMPANY

THE Lockport Gas and Electric Light Company distributes in the City of Lockport, power delivered by The Niagara Falls Power Company. The power is delivered at the Power Company's section-house in North Tonawanda and is transmitted to Lockport by a 22,000-volt branch transmission line belonging to the International Railway Company under a special arrangement with that company.

Twenty-two thousand-volt, 3-phase current is received in the transforming station in Lockport, from which point it is transmitted at 2,200-volts, 2-phase, to the larger users of power for manufacturing purposes, and to the lighting company's distributing station. At the latter point, by means of step-down transformers and converters, it is further transformed into direct current for public and domestic lighting, and for other purposes for which direct current may be required. The amount of Niagara power used is approximately 500 h. p., the additional requirements being met by a local water power development taking water from the Erie Canal.

PART IV

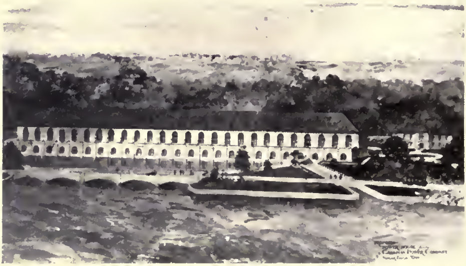
NIAGARA POWER DEVELOPMENT IN CANADA

Canadian Niagara Power Company

THE Canadian Niagara Power Company was incorporated by an Act of the Legislature of the Province of Ontario in the year 1892, which act confirms a certain agreement, dated April 7, 1892, with the Commissioners for the Queen Victoria Niagara Falls Park, providing that the Power Company shall have the right, for one hundred years, to construct and operate works within the Park, by means of canals, wheelpits and tunnels for the development of electrical and pneumatic power for transmission, distribution and sale without the Park. This company is an allied company of The Niagara Falls Power Company, which has built the two power houses on the American side heretofore described, and it now has under construction a development of 110,000 e.h.p., 20,000 e.h.p. of which it is expected will be ready for transmission and delivery on December 1, 1904, and 30,000 e.h.p. additional within a few months thereafter, while the water connections, wheelpit and tunnel, have been constructed already for the full 110,000 e.h.p. This company had the first choice of location for power development works within the Park and will be the first power company to produce power on the Canadian side of the Falls.

In general, the hydraulic development of the Canadian power house will be similar to that of the American plants of The Niagara Falls Power Company. The power house is situated in the Queen Victoria Niagara Falls Park, about half a mile above the Horseshoe Falls. The water is taken in from the river through a short canal and forebay, discharged through penstocks into turbines near the bottom of a wheelpit, and carried away to the lower river through a tunnel about 2,000 feet in length.

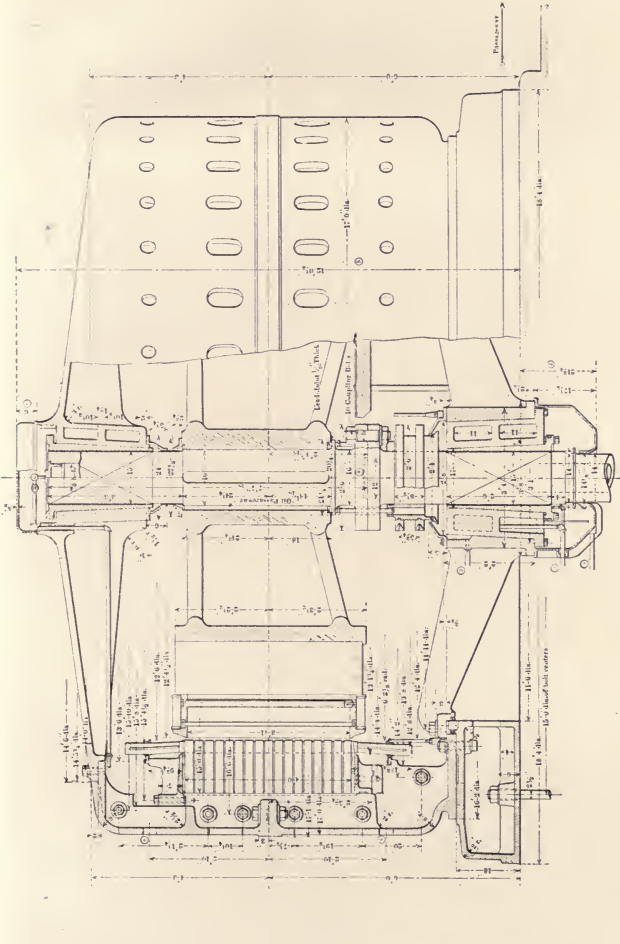
The most distinctive feature of this plant is the size of the generating units, each of which is to have a capacity of 10,000 h.p.,—the largest machines which have thus far been constructed. The plant, when completed, will include eleven of these generators. A unit of this size was adopted for reasons of economy in hydraulic development and in electrical equipment. These 10,000 h.p. units occupy but little more space than those of 5,000 h.p. Thus results a great reduction in length of wheelpit and power house for



Power House
The Canadian Niagara Power Company

a given horse-power output. Furthermore, the generators cost considerably less per horse-power than those of 5,000 h.p. capacity.

The generators will have vertical shafts, and are wound for three-phase current, 11,000 volts, 25 cycles at 250 revolutions per minute. This high generated voltage was selected for economy in local distribution of power. The cost of distributing underground at 11,000 volts, three-phase, is about one-fifth that required for a 2,200-volt, two-phase system. For long-distance transmission step-up transformers have been installed in a transformer house outside of the Park and will be used to raise the voltage to 22,000, 40,000, or



Section and Elevation of 10,000 H. P. Alternator—Canadian Niagara Power Company

60,000 volts, depending upon the distance of transmission. Three-phase was decided upon rather than two-phase for the reason that one less conductor is required, which simplifies cable connections, and because the three-phase system requires twenty-five per cent. less copper for transmission than one of two-phase for the same voltage. Power from this plant will be distributed by means of No. 000 B. & S. triple conductor, lead-covered cables laid in ducts underground.

It is the intention to have cable connections so that the power house of the Canadian Niagara Power Company can operate, if desired, in parallel with either or both of the power houses of The Niagara Falls Power Company on the American side. The output of the Canadian Niagara Power Company will be used primarily for Canadian industries and for public utilities in the Province of Ontario within the range of long-distance transmission from the power house. When used upon the American side, the generated current will be carried across the Niagara River by way of the Upper Steel Arch Bridge, a total distance of about three and one-half miles. This 11,000-volt, 3-phase current will be changed on the American side by step-down transformers to 2,200 volts, 2-phase for paralleling, or will be delivered direct to tenants of the American Company. A part of the output may be sent to Buffalo by a transmission line to be built along the Canadian side of the Niagara river from the Park to Fort Erie, a complete right of way for which has been obtained.

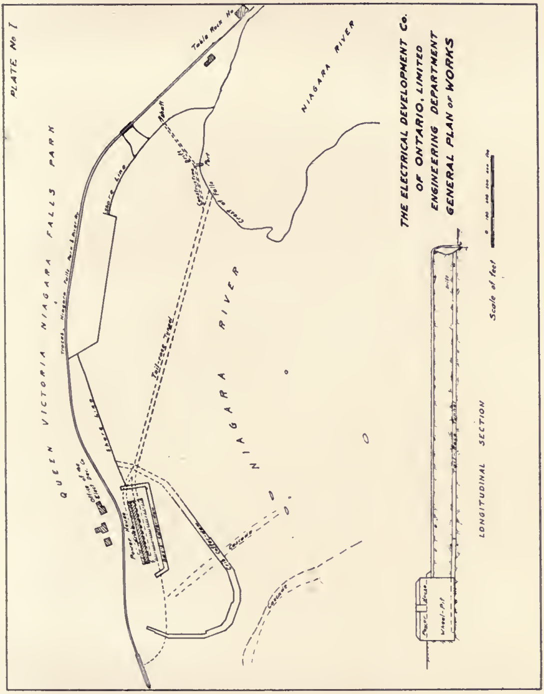
Power House—The Electrical Development Company of Ontario, Limited

The Electrical Development Company of Ontario, Limited, and The Toronto & Niagara Power Company

THE world-wide fame of Niagara Falls has for many years attracted the engineers of all nations, and they have been at work devising means for utilizing the great power in these Falls. So difficult and varied are the many problems connected with the installation of the plants necessary for the utilizing of this power that it has taken the combined efforts of the best engineers of the world to devise apparatus and plant which have made possible the development of thousands of horse-power within comparatively small limits, and the transmission of this power to cities many miles distant.

As the development of power for use within a few miles of Niagara Falls advanced, the progress made was anxiously watched by the citizens of Toronto with the hope that some day the power available on the Canadian side of Niagara Falls might be utilized to furnish light and power to the Queen City. Among the anxious watchers, perhaps the keenest and the ones to realize most the advantages to be derived from Niagara power transmitted to Toronto, was a syndicate composed of Messrs. Frederic Nicholls, H. M. Pellatt and Wm. Mackenzie. From its connection with Canada's greatest developments and chief manufacturing companies this syndicate was probably better fitted than any other combination of business men in Canada to undertake the organization and management of the companies necessary for the development of a large power at Niagara Falls and the transmission of this power to Toronto and other points in Ontario where it is to be utilized.

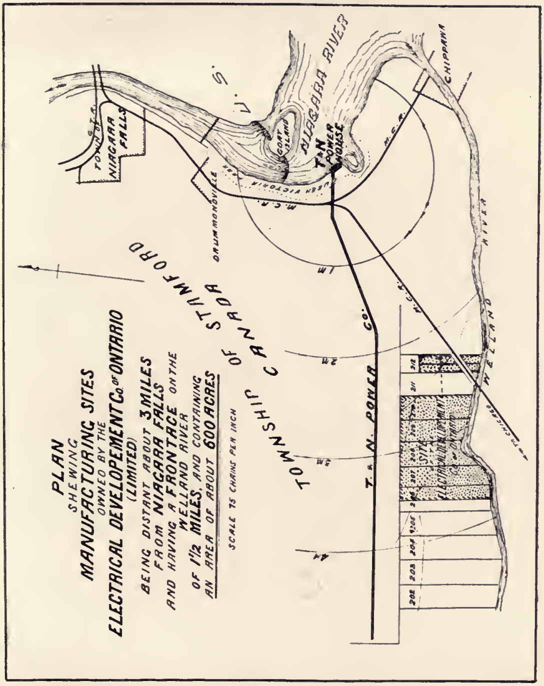
After the long distance transmissions at high voltages in the West and in Mexico had demonstrated satisfactorily the commercial practicability of long distance



transmission, the syndicate proceeded to obtain the necessary rights for a large hydro-electric development at Niagara Falls. On January 29th, 1903, an agreement was entered into between the Queen Victoria Niagara

Falls Park Commissioners and the syndicate granting it rights to take water from the Niagara River at Tempest Point for the purpose of generating electricity to the extent of 125,000 electrical horse-power. On the 18th of February following, the Electrical Development Company of Ontario, Limited, was incorporated by letters patent under the authority of the Legislature of Ontario. This company has a capital stock of $6,000,000. At a meeting of its shareholders, held on March 21st, 1903, the agreement above mentioned which had been made with the Park Commissioners, was acquired by the company. Although the Canadian Niagara Power Company and the Ontario Power Company had already obtained sites by agreement with the Park Commissioners for the location of their power plants, the engineers engaged by the syndicate to select a site chose one which appears to be second to neither of those of the companies just mentioned. Its location on the river bank is such that the flow of ice, which is considerable in the river in the early spring, will not interfere with the operation of the plant, as at this point the ice follows channels some distance from the power house site, and only occasional small gatherings of ice will pass near the power house. On account of the construction of the tail race tunnel directly below the Niagara River in a straight line between the wheel-pit at the power house and the foot of the Horseshoe Falls, a shorter tail race than that of the Canadian Niagara Power Company will be obtained, and also it will be much shorter than the supply pipes of the Ontario Power Company.

While the agreement with the Park Commissioners was being considered, a second company—the Toronto and Niagara Power Company—was organized by the syndicate above mentioned. The charter of this company gave the right to transmit power and acquire a right of way for the transmission line. Incidentally the right of expropriation of lands was obtained. This company has already purchased a right of way seventy-eight and fifty-eight hundredths miles in length between Niagara Falls and Toronto, eighty feet wide at its narrowest point. The line is practically straight between the limits of the City of Toronto and



Burlington Beach, near Hamilton, and also between Burlington Beach and Niagara Falls. Its width and grade are such that a double track railway can also be operated upon it after the construction of the transmission lines, should future developments warrant it.

With a view to providing manufacturing sites for industries which may desire to locate near Niagara Falls in order to use the power of the Electrical Development Company, some 530 acres of land have been purchased fronting on the Chippewa River, situated about two miles from Niagara Falls, and only three and one-half miles from the point where the Chippewa River has entrance to the Welland Canal as shown on the map on page 171. These lands have a river frontage of one and one-half miles. It is expected that indus-

Constructing Coffer Dam at the Cascade
The Electrical Development Company of Ontario, Limited

trial plants of various sorts, and especially electrochemical plants, will be established on this site.

On the second of April, 1903, work was begun at Niagara Falls and has been energetically pushed ever since both as to the development at Niagara and as to the transmission plant. The general plan of development at the hydraulic plant of the Electrical Development Company may be described as below and is further shown by the plan and illustrations. The swift moving waters as they passed Tempest Point previous to the commencement of work by the Electrical Development Company, seemed to defy human powers to construct in their swiftest part a coffer dam which could reclaim the river bed which has been covered by Niagara's flow for countless centuries. But the irrepressible engineer has by pluck and skill constructed a coffer dam as shown on the plan. As the work on the coffer dam progressed, the difficulties of its construction which had appeared serious enough in the beginning grew greater. When the cascade indicated on the plan was reached instead of a depth of eight feet of water, as had been expected, twenty-four feet of water were found, and that, too, just where the water falls about eight feet. The coffer dam has been successfully completed and has unwatered about eleven acres of the river bed, where a gathering dam and the power house are being constructed as indicated on the plan.

The gathering dam will be of concrete, capped with cut granite. It will extend into the river for about 750 feet at an angle of about 60° from the line of the power house. The height will vary from 10 to 23 feet. This dam is intended to divert toward the power house an amount of the river's flow sufficient for the development of the maximum capacity of the plant to be installed. Incidentally, within this dam the level of the water will be raised about eighteen feet above its former natural level, thus increasing the effective head at the wheels. At the power house end of the dam will be a spillway of large capacity, and over this such an immense flow of water will take place that it is expected that the ice and other debris deflected by the arched wall, further described below, will be carried away and discharged into the river on the lower side of the dam.

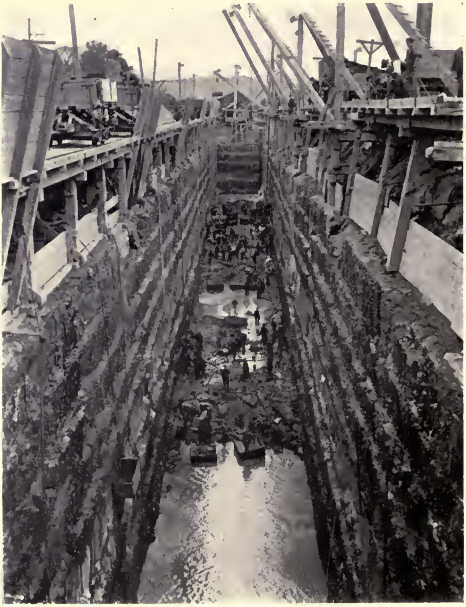
The power station will be located practically on the original shore line and parallel to it. The length will be about 500 feet, the width 70 feet, and the height 40 feet. The inside walls will be of stone, and it is the intention of the company to construct such a building as will harmonize with its surroundings. The Park

Commissioners have approved of the plans submitted, which show a building whose style of architecture on the outside is of the Italian Renaissance. The front elevation will show a centre bay containing the main entrance and two end bays. Between the centre and end bays will be a colonnade with a loggia. Along the loggia will be large windows, through which it will be possible for the public at large to view the generator room. Suitable entablature, balustrading, etc., will be employed to obtain harmony in the design. The other

Main Coffer Dam
The Electrical Development Company of Ontario, Limited

sides of the building will be comparatively plain. In plan the building will be composed of three portions; the entrance with offices, board and visitors' rooms leading off from it; the main generator room; and the screen and gate room. Around the generator room there will be a tiled brick dado about ten feet high. Above this to the roof light yellow brick will be used. In the front centre above the main entrance and projecting into the generator room there will be a gallery containing the switchboard and the indicating and recording instruments for all of the electrical apparatus. This gallery will be reached by the elevator. The generator room will contain eleven generators, of 8,000 kilowatts capacity each, all in line in the centre of the room. They will be of the vertical inside revolving field type, with twelve poles, 250 revolutions per minute, and delivering a three-phase alternating current of twenty-five cycles at twelve thousand volts. The weight of each generator will be about 400,000 pounds and that of the revolving part about 141,000 pounds. The side of the power house toward the river will be carried on a wall in which, below the water level, will be arched openings. Through these openings the water will pass to the screens, gates and penstocks, but the outside face of the wall will divert ice and other floating substances to the spillway at the end of the gathering dam as already described. There will also be a spillway at the down-stream end of the screen room over which the debris gathered by the screens will be discharged into the river. The gates will be operated by electric motors. Below the generating room will be the wheelpit, about 416 feet long, 22 feet wide, and 158 feet deep. The pit will be lined with masonry and will have several floors or stories. At various points will be store and pump rooms, etc. The penstocks leading from the gate and screen rooms to the wheels, which will be at the bottom of the pit, will be steel tubes ten feet six inches in diameter. The wheels will discharge the water through draft tubes into the side discharge tunnels to be described below. They will have two runners—right and left—and will be connected to the generators on the main generating floor by means of hollow steel shafting about 115 feet in length with solid couplings. The moving parts of the generators and wheels will be carried under normal conditions upon the oil thrust bearings. An adjustable floating piston will carry each wheel shaft, if for any reason the oil thrust bearing does not work. The pressure upon the piston will be applied automatically. Each unit will be provided with its own independent oil pump for the oil supply. Suitable air compressors will be provided for cleaning the generators and other uses about the plant.

Besides the above described equipment the power station will contain two 125-volt exciters of 300-kilo-



Wheel Pit, June 7th, 1904
The Electrical Development Company of Ontario, Limited

watts capacity driven by water wheels, and three exciters driven by induction motors; the necessary cables, bus-bars and switches for properly controlling the generators and distributing the electric current; the governors for the water wheels; a machine shop for general repairs and all the equipment necessary for the successful operation of the plant.

The discharge water from the draft tubes will be carried away by two discharge tunnels—one on each side of the wheelpit. The draft tubes will enter these tunnels at the bottom, thus forming a water seal. Six of the large wheels will thus discharge into one tunnel and five into the other. At a point about 165 feet from the wheelpit these two tunnels will come together and form the main discharge tunnel which will convey the water to the base of the Horseshoe Falls, at a point about midway between the Canadian and American banks. The form of the tunnels is generally described as horseshoe. The main tunnel has an extreme width of about twenty-four feet and a height of about twenty-six feet. The velocity of the water in the main tunnel under maximum load will be about twenty-six feet per second.

Before work in the main tunnel was begun some preliminary work was necessary in the form of a construction drift, shown on the plan. This drift started from a shaft which was sunk on the river bank opposite the crest of the Horseshoe Falls and had for its objective point the lower end of the main tunnel. Until the face of the Horseshoe Falls was almost reached and only about fifteen feet of wall remained, no difficulties of exceptional character were encountered, and the tunnel had been relatively dry. A fissure in the rock here allowed so much water to enter that it was impossible to keep the tunnel dry enough for working. After fighting the water with varying success it was decided to explode a large quantity of dynamite close to the wall between the tunnel and the face of the Falls. Besides this, the eighteen holes which had with difficulty been drilled in the wall were filled with dynamite and all were exploded together, after the drift had been allowed to flood. The explosion caused an opening into the face of the cliff, but, unfortunately, so near the roof of the tunnel that it was impossible to work at the opposing wall from the inside.

At this point the resident engineer undertook heroic measures and called for volunteers to crawl along the ledge on the face of the cliff behind the Falls to the opening which had been made. Two volunteers made the first trip, and finally with great difficulty, large quantities of dynamite were placed against the wall at the end of the tunnel, and it was blown away sufficiently to allow the water to run out of the tunnel. In the main tunnel, which is now nearly completed, there is no infiltration whatever.

Main Tail Race Tunnel Above Spring Line
The Electrical Development Company of Ontario, Limited

The Toronto and Niagara Power Company will receive at its step-up terminal station through underground conductors the electric power generated by the Electrical Development Company. The terminal station will be located on the top of the Niagara embankment about fifteen hundred feet from the generating station, near the tracks of the Michigan Central Railway, and sufficiently far from the river to be free from the dangerous deposit of ice formed by the spray from the Falls. This terminal station will be about 200 feet long and 65 feet wide. The current will be delivered from the generating station at approximately 12,000 volts. The transformers are so designed that current may be distributed from them at forty, fifty or sixty thousand volts. Leading from the terminal station will be local circuits at 12,000 volts and other circuits at higher voltages depending upon the length of the transmission line and the quantity of power to be transmitted.

For the transmission line a right of way has been

Offices
The Electrical Development Company of Ontario, Limited

either purchased or arranged for, from the terminal station at Niagara Falls to the terminal station on the northern boundary of the city of Toronto. It has an average width of over eighty feet. At the crossing of the Welland Canal, towers, carrying the conductors, will be erected of such a height as to allow passage of ships below the conductors. At Burlington Beach, the canal connecting Lake Ontario with Burlington Bay will be crossed, and high towers will also be used at this point. Generally speaking, and with the exception of the rise to the Niagara plateau near Grimsby, and the ravines in the township of Pelham, the right of way passes through practically a level country, and will present few difficulties for construction.

The transmission lines to Toronto will consist of four three-phase circuits to be operated at 60,000 volts. These four circuits will be carried on two lines of steel towers, each line carrying two circuits. The towers will be constructed of galvanized steel angles bolted together. They will be 46 feet high, having a base 14 feet by 12 feet. Lengthwise of the line the towers will have a uniform width of 14 feet, top and bottom, while crosswise of the line the base will be 12 feet, the two sides coming together at the top of the tower. Cross bracing after the general design of wind-mill towers will be used. At the top will be a cross arm in the form of a steel pipe on which will be placed four steel pins carrying insulators. The fifth and sixth pins will be supported on vertical steel pipes which will be supported at the point where the sides of the tower come together. The towers are so designed that they will withstand with safety a side strain of 10,000 pounds applied at their tops. They will be erected at intervals of about 400 feet on the straight line. At curves a less spacing will be used so that the strain upon the tower will be within safe limits. At points where ravines are crossed or abnormal conditions exist, special towers will be provided.

Porcelain, brown, glazed insulators, having three or four parts according to the manufacturer, will be used. Their approximate dimensions will be, diameter of top of umbrella, 14 inches; height over all, 14 inches. The parts making up the insulator will be cemented together, and the insulator itself will be cemented to the steel pin.

The conductors will be carried upon the insulators which will be so placed upon the tower that the conductors will be located at the points of intersection of the sides of an equilateral triangle having a horizontal base of six feet. The conductor will be composed of six strands of hard drawn copper wire forming a cable, the combined area of the strands being 190,000 circular mils. This wire is being specially drawn with a view of obtaining a high conductivity and at the same time a high tensile strength and elastic limit. The results of tests upon samples of the wire have been very satisfactory, and show that an elastic limit exceeding 35,000 pounds per square inch can be obtained with an ultimate tensile strength of over 55,000 pounds per square inch. In fixing the spacing of towers, and the sag to be allowed, maximum conditions of wind combined with

A Portion of the Unwatered Area
The Electrical Development Company of Ontario, Limited

sleet and a low temperature have been provided for. The conductor, which will be supplied by the manufacturer in lengths of 3,000 feet, will be joined by twisted copper sleeves unsoldered. Copper tie wires will be used.

At various points in each circuit will be placed lightning arresters of ample capacity, each lightning arrester having a knife switch for disconnecting it from the transmission line.

The step-down terminal station will be located at the Toronto end of the right of way just outside of the northern boundary of the city of Toronto. This station will be similar in design to the step-up terminal station. From this station will be laid conductors installed in underground conduits connecting with the substations of the Toronto Electric Light Company, and the Toronto Railway Company.

Birdseye View Showing Power House Under the Cliff—The Ontario Power Company

The Ontario Power Company of Niagara Falls

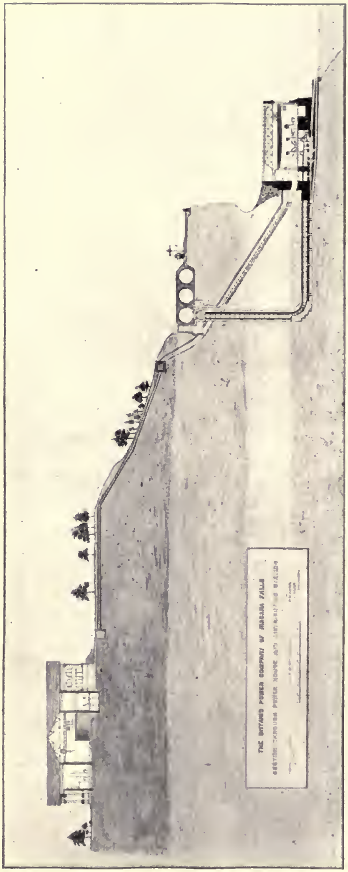
GENERAL PLAN

NIAGARA River descends more than 200 feet between the upper line of breakers opposite Dufferin Islands and the foot of Horseshoe Falls. To utilize this head of water, the Ontario Power Company has laid a pipe from an intake at these islands for more than a mile down stream along the Canadian bank of the river, and then dropped it to an electric generating station at the water level in Niagara canon opposite Goat Island. With the intake of the pipe line above the upper rapids, and the power house in the canon below the falls, nearly 55 feet are added to the head of water available from the cataract alone. This pipe line also passes the series of cascades that extends three-fourths mile up-stream from the falls, and reaches smooth water for the forebay, so that frazil ice will be avoided. Located in the canon near the river level, the power house will require neither vertical generators at the tops of towering shafts, nor a long tunnel to carry off the tail water.

Electrical energy developed near the base of the cataract passes up through cables and conduits in the cliff to a transformer house above for distribution and transmission. Queen Victoria Park is the site of this hydro-electric system from intake to power house, but the transformer station is located on the land of the company.

The distinct features of this power development include the following:

A large, deep forebay with a smooth water sur-



The Ontario Power Company

face, and a series of ice screens swept clear by cross currents.

Forebay and penstocks connected by a line of the largest steel water pipe in the world.

Not less than 175 feet of effective head on turbine water wheels.

Horizontal turbines and electric generators direct coupled at the bottom of the canon.

The discharge of tail water from the draft tubes directly into the river.

All main switching and controlling apparatus located in a distant transformer station instead of at the power house.

Isolation of each unit of electrical apparatus consisting of a generator, its transformers and all intermediate connections.

CAPACITY OF THE WORKS

Plans now under way provide for the diversion of not less than 11,700 cubic feet of water per second from the Niagara River at the Dufferin Islands, the transmission of this water to the power house through steel pipes, and for the development therefrom of 135,000 kilowatts or 180,000 electrical horsepower by eighteen generating units.

The immediate development, now well advanced toward completion, includes the entire intake works, one of the three steel pipes from the intake to the cliff above the power house, penstocks from this pipe to six pairs of main turbine water-wheels, and six 10,000-h.p. generators with exciters, transformers and accessories. One-third of the complete power house, and one-third of the transformer station, will be built at once to contain the water-wheels, and the electrical apparatus just named.

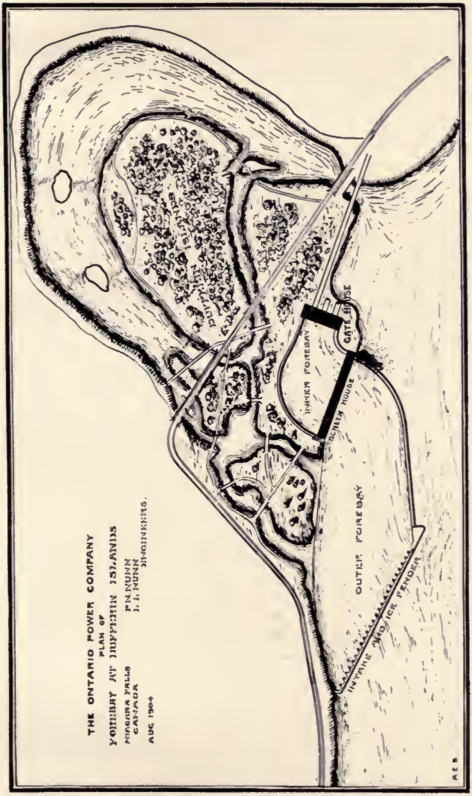
THE INTAKE

Dufferin Islands, at the head of which the intake works are located, mark a deep indenture in the Canadian shore of the river just where its rush toward the cataract begins to quicken. Toward this indenture the waters strongly set and after passing the intake and ice curtain they are caught between converging walls that extend down to the screen house and form the sides of the outer forebay. On passing through the screens from the outer to the inner forebay, the water changes its direction of flow by almost a right angle, and completes a reverse quadrant between the screen house and the gate house.

More than double the volume of water that can be drawn from the forebay by the steel pipes is intercepted by the up-stream face of the intake, and much is there deflected to form a cross current and carry away ice. This deflection is brought about by the intake construction, which consists of concrete piers and curtain wall, the latter reinforced with steel. These piers and the solid curtain that connects them, rise to elevation 560, or 5 feet above the water level. The curtain drops 12 feet between the piers to within 6 feet of the river bed, and 7 feet below the normal level of the river. In this way a strong current across the face of the curtain wall is set up and will carry floating ice with it.

Like the walls of the outer forebay, those of the inner one constantly converge. The intake and ice diverting curtain make an angle of about 45 degrees with the centre line of the forebay and is 618 feet long. On a line at right angles to this centre line and at the up-stream end of its river wall the width of the forebay is 420 feet. Where the turn to the screen house begins, the side walls of the forebay are 295 feet apart, and this house connects the two walls with its length of 320 feet. The gate house closes the down-stream ends of the forebay walls and is 120 feet in length.

At the intake and ice screen the normal depth of water is 13 feet and its velocity about 3 feet per second. Across the line of greatest forebay width at 420 feet the current is 4.7 feet per second and this



The Ontario Power Company

velocity is maintained down to the line of 295 feet width where the depth of water is 12 feet. Between this last named line and the screen house the depth of water increases to 20 feet and its velocity drops to 2 feet per second. After passing the screen house the floor of the forebay continues to drop until a depth of 30 feet is reached at the gate house, where the velocity is 3.4 feet per second.

In the outer forebay, bounded by the river wall, the islands, the intake and the screen house, the area is 8 acres.

The inner forebay extends between side walls from the screen house to the gate house and has an area of 2 acres. All of this forebay area of 10 acres lies in the normal bed of the river just outside of the Dufferin Islands, and leaves their former area undiminished, while several entirely new islands of considerable area have been added. Besides the line of intake piers and ice curtain, 618 feet in length, which extends diagonally out from the bank above the islands, the larger or outer forebay is separated from the river by a confining wall some 780 feet long, which describes a curve from the outer end of the intake down to the screen house.

On the river side the screen house and the gate house are connected by an artificial island and a retaining wall. The confining wall along the river side of the entire forebay sets a little inside of the highest line of cascades and is sunk one to five feet below the outside bed rock of the river. In order to obtain the required depth of water in the forebay a large amount of limestone bottom which forms the river bed at that point had to be excavated. This removal of rock from the bed of the river left a natural limestone wall along the bank and island side of the smaller or inner forebay, and this natural wall was supplemented with concrete.

Intake piers that support the ice curtain, as well as the river wall of the entire forebay, the foundations of the gate house, and the head block were also laid with concrete. The retaining walls were laid in sections with dove-tail joints, and their cores were made up in large part of irregular blocks of limestone spaced with at least several inches of concrete between. For all this work the regular concrete mixture was one part of Portland cement, three parts of sand and five parts of crushed stone from the river bed.

At the intake and along down the forebay to the gate house the low water elevation was taken as 553 feet above tide water. The top of the retaining wall on the river side of the forebay from the intake piers to within 100 feet of the screen house has an elevation of 553 feet, or just the low water level of the river. At a point 100 feet up-stream from the screen house the top of the wall on the river side of the forebay drops to an elevation of 551 feet and runs at this height for a length of 50 feet, then drops to a 549 foot level and maintains that height down to the screen house.

When water at the intake is at extreme low level, there is thus a discharge of approximately 50 x 4 or 200 square feet cross section over the 50 foot spillway next to the screen house, and a discharge of 50 x 2 or 100 square feet cross section over the 50-foot spillway next up-stream. These spillways consequently will create a strong surface current right across the front of the screens, and this tends to sweep all ice that may have passed the ice curtain at the intake out into the river. With high water the entire river wall of the forebay as far down as the screen house acts as a spillway. This interferes in no wise with the regular action of the deeper weir section, in reality supplementing it throughout the entire length of the wall.

The screen house foundations and screens rise to an elevation of 560 feet, or 7 feet higher than low water, and 25 feet above the floor of the forebay at this point. Both walls of the inner forebay stand at this elevation of 560 feet, from the screen house

The Ontario Power Company

down to the gate house, where the floor level of the forebay is 525 feet. Just in front of the gate house at the river end there is an ice run 5 feet wide, 3 feet high, and with its sill at an elevation of 550 feet in the forebay wall. This provides a further means of discharging ice and floating debris at this point.

Across the floor of the outer forebay, just in front of the rack in the screen house, there is a trench two feet wide and four feet deep to catch sand and gravel that may be moving along the floor of the forebay. This trench connects with the river through an arched opening in the forebay wall, and is swept clean when required by a strong discharge current.

At the gate house as well as at the screen house there is an ice screen, and it is expected that these two will clear the water of all floating objects that pass the solid curtain at the intake. An artistic stone structure with steel trusses covers the entire length of the screens, and its roof forms a broad promenade commanding an exceptionally fine view of the rapids. The gate house is also of stone, and of artistic design. Entry to each main pipe at the gate house is closed by a steel gate 18 feet square, of the "Stoney" type, which rests on a steel sill when down. This gate is counterbalanced and runs between roller guides so that the work of operation is done by a motor of only 5 h.p.

THE PIPE LINES

Starting from the gate house three steel pipes will follow the river bank through the Queen Victoria Park to the top of the cliff above the power house and there connect with eight penstocks each. From head gates to the nearest penstock the length of each of the pipes is 6,180 feet, and the most distant penstock is nearly 1,000 feet farther down stream.

Each of the main pipes has an inside diameter of 18 feet, the largest used anywhere to convey water, and connects with six penstocks of 9 feet diameter, and two of 30 inches diameter, at the top of the cliff. At the gate house the centre elevation of each 18-foot pipe will be 534 feet, or 19 feet below the low water level in the forebay, and the centre elevation of the same pipes at that point on the cliff where the first penstock is connected will be 506 feet, showing a 28-foot drop in the pipes. Each of these 18-foot pipes with its eight penstocks conveys water for the development of 60,000 electrical horse power besides that delivered by the exciters. For this power development each pipe will deliver about 3,900

Sand Blasting the Pipe
The Ontario Power Company

cubic feet of water per second when its connected generators are fully loaded, and the velocity of the water in the pipe will then be nearly 15 feet per second.

Steel plates ½ inch thick and joined with double rows of one inch rivets are used to form the 18-foot pipes, and these plates are reinforced by 8-inch steel bulb tees, or deck beams, bent to the radius of each pipe and riveted to its upper half at intervals of four feet throughout its entire length. From head gates to penstocks the pipes will lie in trenches excavated for the purpose through the Park, and with these trenches filled with earth the support thus given to the lower halves of the pipes makes unnecessary the use of circular beams to reinforce those parts. Before each pipe is covered its outside surface is cleaned by sand blast and painted to prevent rust, and conducting terminals are also attached to it at intervals of four feet. These terminals are connected to a conductor for carrying off stray electric current which might otherwise cause damage by electrolysis. The earth covering varies in depths with the surface of the park. One of the three pipes is included in the section of the work now nearing completion.

Each 18-foot pipe turns up into an open relief and spillway at its end on the cliff where the penstocks are connected. These spills serve to reduce fluctuations of head and pressure at both increase and decrease of loads.

The spillways being open and provided with overflow pipes send any excess of water to the river when the load is suddenly reduced, and thus prevent any dangerous rise of pressure.

THE PENSTOCKS

Eight penstocks will connect with each 18-foot pipe at the top of the cliff, and drop through shafts and tunnels in the rock to the power house in the canon below. These penstocks are divided into four pairs, each of which has its own shaft and tunnel. Six of the penstocks, forming three pairs, have a diameter of 9 feet each and carry water to the wheels of six main generators. The two smaller penstocks are each 30 inches in diameter, pass through the same tunnel, and deliver water for the wheels of two exciters. A chamber beneath the point where each pair of penstocks joins the main pipe provides room for their valves and for the electric motors by which the valves are operated.

Each 9-foot penstock for the turbine of a generating unit rises to the wheel centre at elevation 373 after passing through a tunnel of somewhat lower level, so that the drop between the centre of the 18-foot pipe and the centres of the main wheels is 133 feet. The exciter penstocks reach their wheel centres at elevation 380.8 or about 125 feet below the centre of the main pipe on the cliff above.

THE TURBINES

A twin turbine wheel mounted on a horizontal shaft in the power house will be direct connected to

Interior of Pipe
The Ontario Power Company

each 7,500-kw. generator. Each of these wheels has a diameter of 6.5 feet at the tips of the runners, and operates at 187½ rev. per min. The pair of wheels on each shaft is mounted with the centres of their cases 18 feet, 2 inches apart, and between the cases there is a draft tube and also a bearing for the shaft. Before delivering its water to the turbine the 9-foot penstock divides into two branches, one for each wheel. Each main penstock is also provided with two relief valves that discharge into the tail race when open.

The two draft elbows from each pair of main turbines will unite near the floor line of the power house in a single tube formed in the concrete foundation. This concrete draft tube has a total length including its curved portion of nearly 50 feet. It is circular in cross section and 10 feet in diameter near the floor level, but changes lower down to a rectangular section of equal area. Each concrete draft tube will terminate in a tail race beneath the foundations of the power house, and this tail race will be provided with a wall of overfall section on its river side. The top of this wall is at elevation 349.5, or 7 feet above the mean water level of the river outside.

When all the turbines are in operation at full load the surface of the water in the tail race will rise to about 353.2 feet in elevation, so as to give a discharge nearly 3.5 feet deep over the crest of the waste wall.

Electric exciters and their direct connected turbines will be located on a raised gallery on the side of the station farthest from the river, and the oil actuated governors controlling the speed of all turbines will be also mounted upon this gallery. This location was selected to bring them within easy reach of the attendant stationed on this gallery, which overlooks the entire generating station. From it the operation of the station will be conducted. Each exciter will be of 500-h. p. capacity and will be driven at 300 rev. per min. by a 39-inch impulse wheel mounted upon the exciter shaft. The effective head on the exciter wheel will be the same as that on the main turbines. The wheels for each exciter will pass 50 cubic feet of water per second at full load.

ELECTRIC GENERATORS

Three of the eighteen main generators provided for by the general plan will make up the first installation. Each of these generators is rated at 7,500 kw., or 10,000 e.h.p., and to deliver three-phase current of 25 cycles per second at 12,000 volts when operating at

187.5 rev. per min. The armatures in these generators are stationary and the magnets rotate on horizontal shafts. The bed plate of each generator measures 26 feet, 7 inches, at right angles to the shaft, and the length from the centre of coupling to the end of shaft is 20 feet, 2 inches. For each generator and its pair of direct connected turbines the floor space will be about 20 by 49 feet. The revolving part of each generator weighs 82.5 tons, and the total weight of the machine is 204.6 tons. The revolving magnet has a diameter of 15 feet, 2.5 inches, and carries 10 poles. In the external armature the dividing line of its halves is the horizontal diameter. The external diameter of the armature casing measures about 21 feet, 6 inches. The shaft diameter is 21 inches.

Two exciting dynamos, of 500 h.p. capacity each, will be provided for the six main generators that are driven by the water from one of the 18-foot pipes. Direct current at 250 volts will be delivered by these dynamos, and used for the operation of lamps, motors, oil switches, and for charging storage batteries, as well as for exciting the generator magnets. One of the 500-h.p. dynamos will have sufficient capacity to excite the magnets of six main generators, with the second dynamo of like capacity held in reserve. Two of these exciting dynamos direct connected to their respective wheels are being installed with the first three of the main generators.

SWITCHES AND SWITCHING

Generators at the power house in the canon are to be connected and controlled by apparatus in the transforming and distributing station some 550 feet distant and 255 above on the cliff.

This distant control removes from the power house the possible dangers incident to the operation of high voltage switches for generators as well as transformers, and also concentrates the management of both in a single operating room.

At the power house will be located 250-volt switches that connect the exciters with generator magnets, motor, control and lighting circuits, and with a storage battery that is located in or near the distributing station.

The power house will contain also time limit and overload relays for the main generators to protect them from overload by opening any generator switch when the load for which the relay is set is exceeded. Either or both of the exciters may be used at any time to supply current for the purposes named, including the excitation of magnets at any

Site of Power House
The Ontario Power Company

of the six generators that are driven by water from the same 18-foot pipe.

Among the important control circuits that may be operated from the power house will be those of the motors in the valve chambers under the 18-foot pipe which admit or shut off water from the 9-foot penstocks of the main wheels. Each of these valve motors is of the induction type and is rated at 30-h.p.

Aside from the necessary operation of the switches already named at the power house, the speed, voltage and connections of the main generators will be controlled at the distributing station. To this end the distributing station will contain a complete group of indicating instruments for each generating unit and is connected by telephone with the power house. In the switch room at the distributing station the oil switches for the 12,000-volt generator circuits will be mounted in concrete cells and grouped separately for each unit. These switches are to be all of the vertical plunger type and operated by electromagnets.

Three-pole oil switches like those used in the generator circuits will connect the primary coils of transformer groups to the 12,000-volt bus bars, and other three-pole switches of special design will join the secondary coils of transformers to the high-tension bus bars. Each circuit will pass through two of these special switches before it reaches these bus bars. As these switches must break a maximum current of 10,000 h.p. at transmission voltage, they will necessarily involve some novel construction, and each is expected to contain 500 gallons of oil.

A complete set of control devices for the circuits of each 10,000-h.p. unit will be located on a single, isolated pedestal, to prevent the possible communication of trouble from the connections of one unit to those of another, and this pedestal will carry a diagram on its face representing the arrangement of all the connections concerned.

Just back of each control pedestal there will be an instrument stand that will carry a full set of indicating instruments. Each transmission circuit will also be provided with control pedestals and instrument stand like those just named.

TRANSFORMERS

Besides main and control switches and connections the distributing station will contain an isolated group of three single-phase transformers for each main generator. The rating for each of these transformers is 2,500 kw., or 3,300 h.p., a capacity greater than that of any that have yet been built. Each transformer will have a weight of about 40 tons, and will contain 70 barrels of oil. To cool one of these transformers, 10 gallons of water will enter and flow through its case per minute. Pits formed of concrete and connected with a sewer will contain these transformers in groups of three, so that any trouble in one group will not extend to another.

CABLE CONNECTIONS

All of the cables and control wires for the six main generators and two exciters, driven by water from one of the 18-foot pipes, will leave the power house by way of the tunnel that also carries the exciter penstocks, and pass from its top to the distributing station through a line of clay conduits near the surface. The length of this tunnel is about 280 feet, and its angle varies from 33 to 60 degrees. Power cables are carried by tile ducts imbedded in the concrete sides of the tunnels, and broken at intervals for the insertion of steel clamps to prevent sliding of the cables. These power cables are to be paper-insulated lead covered, and protected with layers of jute and stee wires.

The control wires will be suspended from the roof of the tunnel in iron pipes, and will be also clamped at frequent intervals to prevent displacement.

PART V

FROM NIAGARA TO CHICAGO

From Niagara to Chicago

THE Niagara River is crossed by way of the steel cantilever bridge of the Michigan Central Railroad, a structure possessing some features of interest to engineers. From it the cataract is plainly visible on the left, and the dark, angry waters of the narrow gorge for below at the right. At Falls View a magnificent panorama

is spread out before the spectator who stands upon the bluff 150 feet above the crest of the falls, and here the train stops for five minutes to allow passengers to enjoy the spectacle. Far beyond to the south is seen the grand sweep of the rapids of the upper river; directly in front is the magnificent Horseshoe Falls, "The Heart of Niagara," and beyond lies Goat Island and the American Falls, while to the north is the gorge. In the immediate foreground is the construction work of the three Canadian Power Companies, which are pushing rapidly toward completion the development of 375,000 horsepower. The Carmelite Monastery on the bluff just beyond Falls View is interesting on account of the electric heating plant installed by a scientific Brother, one of the first of the kind in the country, and which does all the work of the kitchen and laundry for the entire establishment.

At Welland a glimpse may be had of the Welland Canal, a small but most important waterway, giving access by way of the St. Lawrence River to the most extensive mid-continental water system in the world.

St. Thomas is midway between Niagara and Detroit, and is one of the most important cities of central Ontario. London, with a population of 38,000 is but fifteen miles north, and Port Stanley on Lake Erie is close by. The southern portion of Ontario is a rich agricultural country noted for its fine crops of grain and fruit, and for its blooded stock, which is not excelled by the most favored region of the States. At Windsor the Detroit River is crossed, the entire train being taken upon one of the powerful steel ferry boats of the Michigan Central. The Detroit River is a busy waterway, and from its beauty as well as from its topographical situation has been called the Bosphorus of America. Standing upon the bridge of the transfer steamer by night, and gazing at the moving lights on the river and the constellations upon the tall masts that illumine the city, or by day watching the thronging commerce, the lover of the picturesque will regret the day when the necessities of commerce demand a more speedy passage of the river by bridge or tunnel instead of the more attractive, though brief, sail across the straits.

Detroit has a better class of workingmen's homes, with a larger percentage owned by the occupants than the majority of American cities. Points of especial interest are the water works, located in a beautiful park; the fine Museum of Art; Belle Isle Park, a magnificent island pleasure ground; Lake St. Clair; Mount Clemens, with its saline springs and baths; and the watering places of Grosse Isle and St. Clair Flats where Detroiters take their summer recreation. Nearly 700 miles of electric roads radiate from Detroit.

Ypsilanti is twenty-nine miles from Detroit and is noted for its saline wells and baths, and also for the gardens and greenhouses which supply the Michigan Central Station grounds and dining cars with plants and flowers. It is lighted by electricity and has a fine water system.

Ann Arbor, thirty-seven miles, is one of the handsomest cities in the state. The University of Michigan, ranking fourth in point of attendance among the great institutions of learning in America, is located here. Not only are students present from every state and territory in the union, and every province of Canada, but Japan, China, Egypt, South Africa, England, Germany, Russia, Mexico, Turkey, Hawaii, Porto Rico and Philippine Islands are represented. The Engineering laboratory, several times enlarged, now occupies 30,000 feet of floor space and is very complete.

Jackson, finely located on Grand River, one of the most important cities of Southern Michigan, and a considerable railway centre, is seventy-five miles from Detroit. The city is lighted by electricity, and is supplied with both illuminating and fuel gas. Artesian water is supplied by the Holly System. Grand Rapids, ninety-four miles from Jackson, is the metropolis of western Michigan, and is noted far and wide for its furniture and other manufactories. The city has a fine water power and is well provided with electric light and transportation facilities. Marshall, Battle Creek, Kalamazoo and Niles are fine towns on the main line.

Battle Creek is a thriving town with an interesting history. Its name is often met with in far away places on threshing machines and furniture and especially upon breakfast foods, of which a hundred kinds are manufactured here. The Battle Creek Sanitarium accommodates 800 to 1,000 patients, and maintains branches in the various capitals of Europe as well as in India, Australia and Japan. Its electrical equipment, not only as regards light and power, but in the various apparatus for Finsen and X-ray treatment, electric light and current baths, is interesting and complete. Battle Creek has a water power, being situated at the junction of Battle Creek and the Kalamazoo river. At Buchanan, a quiet little town eighty-six miles from Chicago on the St. Joe river, is a new electric installation which was recently described by an authority as likely to be one of the most permanent and financially successful water power electric plants in the country.

Michigan City, the southernmost port on Lake Michigan and noted for its curious sand dunes, has considerable manufacturing and is well lighted by electricity.

Between New Buffalo and Chicago (Kensington) the Michigan Central Railroad has had in operation for some time a telegraphing system, by which a single wire is employed simultaneously for telegraphing and telephoning.

Chicago is reached after a pleasant ride along the shore of Lake Michigan, whose waters sparkle in the sun, with views of Jackson Park, the Field Columbian Museum and the Chicago University passing in quick succession as the train passes by, and almost before one realizes that he is in the heart of the great, bustling city of Chicago, the train rolls into the Central station on the Lake Front.