HOW NIAGARA'S POWER WILL BE UTILIZED.

By Coleman Sellers, C.E.

The practical minded man standing before Niagara Falls may well be pardoned for viewing that majestic and beautiful sheet of tumbling water as a huge and powerful mill-dam. His observation is entirely sustained by the facts in the case. The picturesqueness of the spot will be maintained by the two govern-

ments owning it, but, in the meanwhile, the Niagara Falls Power Company is constructing a tunnel that will divert from the Falls water sufficient to develop 100,000 H. P.

It takes most visitors to the Falls of Niagara some little time to realize that Canada lies due south as they enter Niagara Falls village by the railroad from Buffalo. This changed condition is owing to the sudden turn in the river. The Niagara flows west to reach the Falls, with the breast of the American Falls facing towards...
the northwest, and the mighty cataract there pours its waters into a gorge narrowed to only a quarter of a mile wide, and then turns almost at a right angle and flows with a course east of north towards the Suspension Bridge and west of north from the Suspension Bridge to the great whirlpool. The points of the compass, so puzzling to newcomers, must be borne in mind in following a description of the place and of Niagara Falls as a source of power.

All rapidly flowing streams may be used for power where nature, as in this case, has planned a sudden fall or man has erected a barrier to form a pool of still water, which pool becomes the mill-dam or storage reservoir. From the mill-dam, canals or mill-races carry the water to the water-wheels, and from the water-wheels on a lower level a tail-race carries "the water that has passed" to the stream below the dam or fall. The water exerting its power through the wheel, has a power measured by volume, and by head, or the difference of level between the upper and the lower streams. The value of a water-power is somewhat dependent upon the distance the water has to be carried by canal from the stream to the mill or from the mill to the lower stream. The mills close to the dam may have the use of a head as great as the height of the dam-breast, and in some cases mills farther off may, by reason of the
NIAGARA'S POWER WILL BE UTILIZED.

continued fall of the river bed below the falls, find a greater head available at a considerable distance than close to the dam-breast. The head, however, may be lost by reason of the distance the water is carried before it is used, hence length of canal or mill-race is an important consideration in the value of water-power mill-sites. A mighty torrent such as at Niagara Falls, will yield power at any point in small amounts. Niagara Falls, however, considered as a mill-dam, has a breast nearly a mile wide; and water drawn from the pool above the rapids, must either be carried a mile or more to the wheel on the bluff below the falls, or have a tail-race dug through the rocks a mile or more long from a wheel operated near to the pool. The long tail-race is the foundation of the present enterprise.

Among the various gaugings that have been made of the quantity of water that flows over the Falls, 265,000 cubic feet per second has been accepted as reliable, representing at 216 feet fall about 4,750,000 effective H. P. The quantity of water in the Great Lakes is so vast in amount that it could be gradually drained off and fed over the Falls at this rate of flow without any fresh supply from rainfall for at least a century. In other words, it would take, with a leakage of 265,000 cubic feet of water per second across the rocky barrier, 100 years to drain the upper lakes, were such a course possible. The outflow of the lake basin is about half of its rainfall, and the volume of the water in the lakes including Lake Ontario is thought to be about 6,000 cubic miles.

The water that issues from the bluff below the mills at Niagara Falls has been called the Bridal Veil. This veil represents a loss to the Falls proper of 800 cubic feet per second, which loss, added to the 800 taken by the canal, and 100 by other users, points to at least 1700 cubic feet per second having already been taken without perceptible decrease in the torrent. The present
enterprise will take but an insignificant portion—not more than four per cent.—of the water that passes over the crest.

The theoretical value of the water that passes over the crest of this mighty dam has been represented as requiring all the coal that is now being mined in the world daily burned as fuel to make steam sufficient to pump back the same quantity of water. All the industries of America could be operated by this power, if it could be wholly transmitted.

In Switzerland, where coal mines do not exist, human ingenuity has been exercised to develop the power of the waterfalls. The engineers expended much ingenuity in transmitting the power from the waterfalls to the distant factories. Their pride has been in wire rope transmission, by means of which power was sent a distance of several miles with quite good results and at a reasonable cost. The water, with crude devices at first, was able merely to operate a few small flax mills here and there, but later, by ingenious mechanical improvements, the same streams were made to yield the power necessary to drive large factories requiring many hundred horse power. Lately there seems to be a preference given to electrical transmis-
THE OLD MILLING DISTRICT AT NIAGARA FALLS.
sion. In no other place in the world, reasonably convenient to markets, does there exist such a power as is presented by the Falls of Niagara. The improvement by electrical transmission and transmission by compressed air points to the possibility of utilizing the power from the waterfalls over an extended area at a price that will compete with cheap coal as carried by rail. Very many years ago, Sir William Thomson, who acted as President of the International Niagara Commission, suggested that the time might come when New York and Philadelphia would be lighted by electricity generated from the Falls of Niagara. This prediction has not yet been realized, but improvements made in modes of transmission give promise of economical development of power certainly to the requirements of the great city of Buffalo.

One of the earliest proprietary maps issued showing the land on the American side of the Niagara River adjacent to the Falls of Niagara, owned at that time by Mr. Augustus Porter, claims to represent the country as it appeared in 1805, or when he came into possession of the property, having taken it up from the Government. In 1847 Mr. Porter issued a circular "to capitalists and manufacturers" with a view to the use of Niagara's water power. Paper mills and other factories already existed there. The efforts of Mr. Porter to rent power resulted in the completion of what is known as the Hydraulic Canal, which carries water to the mills on the bluff below Prospect Park. Mr. Porter's advertisement led to the location of a right of way 100 feet wide for a canal through the town of Niagara Falls to a forebay running parallel with the lower river and supplying mill sites. This canal was built beginning at Port Day. It varies in width from 25 to 35 feet and is not navigable. It thus occupies less than half of the width set apart for the purpose. The quantity of water that is delivered by this canal yields practically 6000 H. P., using say 47,000 cubic feet per minute, which power may be doubled by utilizing the whole of the available fall. Most of the manufacturers who put up buildings and took water from the canal were satisfied with a head of from 90 to 100 feet.

The execution of the present scheme, which originated with the late Mr. Evershed, Engineer of the State of New York, calls for a tunnel from property (about two miles of river front) owned by the company above Port Day, the tunnel being of sufficient capacity to carry off water required to develop about one hundred thousand horse power with a head of 140 feet. Mr. Evershed's
scheme contemplated a continuation of the tunnel parallel with the river on a moderate slope for a distance of about 13,000 feet from the mouth; but with a length of 6700 feet a point is reached convenient as a manufacturing centre, where a central power station may be placed to yield power wholesale, to be transmitted by electricity or compressed air to the city at hand or more distant points. A navigable surface canal has been projected, that shall receive water from the river and be carried toward the west parallel with the railroad to a point where the first section of the tunnel will end. But of this canal it is the present intention of the company to construct only so much of the lower end, running inland northeast towards Buffalo Street, as will give a water supply capable of developing by a central power station the whole amount of power that the tunnel will yield.

The tunnel plan gives a larger acreage of mill sites than is possible by any other scheme, and in many ways is more economical. When we look at the Falls of Niagara in the light of a water power, the wide river above the Falls represents the mill dam and the gorge below the Falls the tail race. The tunnel being constructed is upon the shortest line that can be drawn from this pool above the rapids to the lower gorge, and even then is about a mile and a quarter long. By sinking shafts to serve as wheel pits upon
the property of the company, a fall of 140 feet can be made available, and the water that passes the wheels at this head will then be discharged into the tunnel and carried off and emptied into the lower river at a velocity ultimately of over 20 feet per second. To attempt to carry the same amount of water, yielding the same power at the discharging end of it, by a surface canal, would require a width of between 300 and 400 feet and a depth of from 10 to 15 feet; but such a scheme is inadmissible, as there is no property available for mill sites along the lower bluff, and public feeling opposes it.

The actual work that is now going on at Niagara consists in the driving of the tunnel, the completion of which is to render all after work possible. This tunnel finished and an entrance made from the river by the completion of some portion of the canal that is to feed the mill sites, power can at once be applied to a very considerable amount. The secondary transmission of power contemplates an extension, not only over the new town of Niagara Falls, but also to Tonawanda and Buffalo or elsewhere; the company having secured the rights to transmit power by any known methods. The several attempts that have been made in Europe to transmit power to manufactories from central stations, while in some cases yielding satisfactory returns, in others less profitable, have all demonstrated the convenience of power so transmitted to meet many wants. The readiness with which it can be applied, warranted a rate of rental that has in most cases been profitable to the producing company, even when steam generated by coal for fuel is the primary source of power, as is instanced in the cases of Paris, France, and Birmingham, England, where compressed air is the mode of transmission.

The water power of the Rhone at Geneva, Switzerland, where the volume of water is considerable but the fall only moderate, has been utilized by means of a pumping station from whence the water is raised to reservoirs on the hill and returned to the city by pipes under a much greater pressure, thus enabling a small volume of water to yield in small motors the power and speed required. Where electrical machinery is to be driven by water power and the head of water is not sufficient to give the power and velocity required, the speed must be obtained by gearing up, with attendant loss. In Geneva, small water motors made very sensitive by the regulating devices, are coupled directly to the shafts of the dynamos, and the speed of the wheel is adapted to the requirements of
NIAGARA'S POWER WILL BE UTILIZED.

AMERICAN FALLS FROM GOAT ISLAND.
Niagara's power will be utilized.

the dynamos. At Geneva we see the anomalous condition of the electrical station built on the rapidly flowing river, but not driven directly by the water that passes below the building, but secondarily by the water returned from the reservoirs outside of the city.

In our own country we find large industries scattered over extensive areas where electrical transmission in lieu of shafting has been adopted, even when the power required has to be converted into electricity and not used directly, solely on account of the convenience of the transmission and the facility with which the motive power can be carried to the machine to be driven. Roughly stated, power transmitted by line shafting in the usual manner a distance of say 380 feet, will lose in transmission to that distance fully 11%, while power may be transmitted the same distance by wire rope transmission with a loss of only 1½%, showing how much transmission has to do with the economical use of power.

Compressed air as a mode of transmission in Paris and Birmingham has been popular on account of the many uses to which it adapts itself. Existing steam-engines can be operated to great advantage, particularly when the air delivered from the mains is made to pass through a coil of pipes over a moderate fire and is so expanded and rendered more efficient, the heat so applied being fully five times more efficient than if applied to raising steam from water. For blast purposes the compressed air is used directly by causing a jet of the high pressure air to carry in a large volume of atmospheric air, when volume and not pressure is required, as in cupolas, blacksmiths' fires and in ventilation. Air driven motors are inexpensive and durable, and the air can be carried to the motor when it is not stationary by flexible tubing. Besides the cleanliness of the operation, the fact that the exhaust can be discharged directly into the rooms without detriment, makes it much preferable to steam. In a like way the recent development of the electric motor industries in this country has enabled electricity to be applied in many cases to the exclusion of line shafting for the transmission of power.

The work of the Niagara Power Company is now being carried out in such a manner as to permit the location of large or small industries in which each shall control his power and regulate it according to convenience by having the water-wheel under his own control. This is the ordinary manner with water companies, but with the exception of some of the large milling operations and wood
NIAGARA'S POWER WILL BE UTILIZED.

GOAT ISLAND AND THE HORSE-SHOE FALLS FROM CANADA.
paper pulp making, and in the metallurgical operations by means of electricity where large amounts of power are required to act upon a very few machines, there are very few manufacturing establishments that require, at least in the start, blocks of power exceeding 100 or 200 H. P., 1000 H. P. being sufficient to drive a factory for textile purposes of the largest size usually put into one building. It is the intention of this company to give this class of consumers what they want in the way of power, by means of a properly arranged central station. If the power by electricity or compressed air can be transmitted 20 miles at a loss of only 10% of its power, the force that this is capable of transmitting can be extended over a very much greater area than would be possible if each consumer of power controlled the force by using the water directly.

The work that is now rapidly progressing will result in a tunnel of a horse-shoe form, securely timbered until ready for the brickwork, and then lined throughout in a very substantial manner, provided such lining is found necessary, through the entire length of the tunnel. Two shafts have been sunk, while the entrance from the river permits another gang to discharge the contents of the tunnel from the heading directly into the river, and to thus permit five breasts to be driven at the same time. The power used to effect this work is compressed air, a very large plant having been erected for the work.

The country is seemingly level, but a contour map of the land shows it to afford ample facilities for drainage. The tunnel that is now being built will furnish ample discharge for power to the extent of 100,000 H. P.; but in addition to this, in view of future possibilities, a right of way has been secured for a second tunnel under the town to discharge lower down the river. Upon the completion of the tunnel and erection of a central station, compressed air will be given to the existing factories to take the place of steam, at a lower rate per H. P. than will be possible by fuel, and the boilers can then be used for other purposes where steam is used for heating, or electric motors can be substituted for the engine and boiler.

Most water powers, variable in quantity between high and low water, can be portioned out equally for use all the year round, only so far as their minimum total power goes. At times there may be much water to spare, but this excess of power is variable in duration. All ordinary water powers, however, are in jeopardy from excessive drought or excessive floods, for at times the torrent may
NIAGARA'S POWER WILL BE UTILIZED.

HORSE-SHOE FALLS FROM GOAT ISLAND.
overflow the banks and obliterate all the difference of level that is the source of power. All artificial water powers are liable to the danger of the giving way of the dams erected at great cost. In spite of all these objections, streams yielding power have been the means of building up great industrial centres, where finally steam power exceeds the original water power that was the first attraction. Niagara alone, the great wonder of North America, is capable of yielding a never-varying power, capable of supplying all the demands of many Lowell's and many Holyokes. It alone of all water powers is capable of being made to yield its force in large or small quantities according to man's need. This requires that its power shall be controlled and rendered capable of transmission to the doors of the working people, just as the water they drink and the gas they burn is now delivered to them. Few industries use power in a crude form applied directly to the work, as is the case in the ocean steamer with its engine of 14,000 H. P. merely turning the blades of the propeller. In most cases on land the power must be changed to suit the work to be done, and it is in the changing back and forth from this form of motive force or mode of transmission to others that the loss occurs. The time is now coming when water wheels of great power at Niagara will be made to transmit through a single shaft, as from the engine of the steamship to the propeller, the whole power to a single dynamo or air compressor above ground, which can deliver a cheaper and more convenient power to the consumer than a manufacturer can obtain by means of a single water wheel of his own, unless he be close to the source of power. Beyond this close proximity, the localities served will be made alike by cheap transmission, and this widespread service is what is contemplated by the organizers of this mighty enterprise. Manufacturers are ready to take power from outside when it can be delivered to them on reasonable terms. Such industries as the Baldwin Locomotive Works in Philadelphia, covering many city blocks, generate their own electricity and it is doing the work more conveniently and more economically than the same power transmitted by shafting, only because they can make that electricity cheaper than the companies organized for lighting are willing to furnish it. Many manufacturing establishments are considering the concentration of their generating power with electrical transmission and fully appreciate the advantages of a cheap power transmitted to them in such a way as would free them from the cost and inconvenience of their present steam system and give them additional space.