UTILIZING THE WATER POWER OF NIAGARA FALLS.

According to the census of 1880, the steam and water horse power employed in the manufactures carried on in the United States was 3,410,837, of which 2,185,458 was steam power and 1,225,379 water power. The cost of steam power has been reduced continuously through several years, from improvements made in the construction and operation of furnaces, boilers, and engines, and the thorough dependence which can be placed upon it and exact figures obtainable as to its cost have earned for it a decided preference in many industries, in addition to the main advantage that steam power is always obtainable where desired, while in the case of water power, according to all previous experience, it has been necessary to locate the manufacturing business to be carried on in the immediate vicinity of the waterfall furnishing the power. Still some of our largest industries are and always have been mainly operated by water power, the census of 1880 showing that in cotton goods 148,754 water horse power was employed, against 126,750 steam horse power; in the flouring and grist mill business, 469,987 water and 301,214 steam; in the paper manufacture, 87,611 water and 36,301 steam; and in woolen goods, 53,610 water and 52,897 steam. The industries in which the use of steam most greatly preponderated were: The manufacture of iron and steel, using 380,740 steam horse power against 16,506 water horse power; sawed lumber, 543,242 steam and 278,686 water power; and the vast number of small miscellaneous manufactures, totaling 726,958 for steam, against 161,288 for water power.

The very vastness of the power Niagara at once presents to the eye has long made it one of the most interesting problems for the engineer as well as a fertile subject of speculation to every intelligent observer. The estimates of the total power of the falls vary in somewhat wide limits, but they all place it at several millions of horse power, and it is not an extreme calculation which makes it twice as great as that of the total combined steam and water power at present employed in the whole United States. And yet, although the first rude sawmill was erected at the falls in 1725, there has not been, up to the present time, any adequate attempt made to utilize any considerable portion of this tremendous power. To do this it was obvious that a great initial outlay would be necessary to cut through the high, rocky banks, the required channels for the supply flow, utilization, and escape of the water at its lower level. Something was done in 1873, when the present hydraulic canal was constructed, affording 6,000 horse power, running about a dozen establishments, principally flour mills, but so incomplete was the provision made for utilizing the full head of the water that the tail race of the present mills has, in many instances, a greater fall than that which is used to turn the wheels.

The present Niagara Falls Power Company, whose work thus far forms the subject of our first page illustrations, is making the first noteworthy effort for the development of the power of the falls on a large scale, although the proportion of the total power which will be utilized is so small a fraction of the whole that it is not expected to make a difference large enough to be perceptible in the flow of the river over the falls. The company is the successor of one chartered by the New York Legislature in 1886, and, with the Cataract Construction Company, organized in connection with it, includes among its stockholders and directors some of the leading capitalists and business men of New York City. The company was given power to sell stock to the amount of $10,000,000, and there will be no lack of funds for the full development of the scheme under which it was organized, by which it was proposed to make available 100,000 horse power.

The central feature of the work is the great tunnel, 7,250 ft. long, which will form the tail race, starting from the river at just above the water level below the falls, and running under the village of Niagara, at a depth of about 200 ft. below the surface of the ground, the upper end of the tunnel being beneath a large tract of land the company has purchased adjacent to the river bank above the village. Over 1,400 acres of land has thus been acquired and laid out by the company in mill sites, and for the necessary surface canals, through which water will be supplied from the river to the various wheel pits, all of the latter being connected by lateral tunnels with the main discharge tunnel. The tunnel has somewhat of a horseshoe shape, being 19 ft. wide by 21 ft. high inside of the brickwork with which it is to be lined throughout, and having a cross sectional area of 386 square feet for its entire length. The total amount of excavation, including that necessary for the timbering and brickwork, represented a cross sectional area of 522 sq. ft.

The base of the tunnel at its discharge point in the river bank below the falls is 205 ft. below the sill of the head gate at the entrance of the main canal from the river above the falls, which represents the total fall, of which it is expected about 140 ft. will be practically utilized, the difference being taken up by a liberal allowance for clearance from the wheel pits, incline of the lateral tunnels leading therefrom to the main discharge tunnel, and the incline of the latter, which is made at a grade of 36 ft. to the mile. To prevent damage to the tunnel by the immense rush of water, it is lined on the invert and sides for a distance of 200 ft. back from the discharge point with closely fitting cast iron plates, there being a heavy cast iron frame at the mouth, and the tunnel is lined throughout, including the invert, with four courses, or 16 in., of brick.

In the building of the tunnel three shafts were put down. At the portal, where the top of the river bank is 214 ft. above the level of the water, what is known as the zero shaft was sunk, 10 by 12 ft. in size, and extending down 93 feet, from the top of a ledge to the soffit of the tunnel arch, this shaft being extended up to the top of the bank by open timber work. Shaft No. 2, 2,650 ft. from the portal, was sunk 206 ft. and was 10 by 20 ft. in size, while shaft No. 3, of the same size and 196 ft. deep, was 5,200 ft. from the portal. In putting down the shafts, 140 ft. of the work at the top was through hard bastard limestone, which overlay the Niagara slate or Utica shale, met with for the remaining distance, and through which the main tunnel itself was mostly made, its base, as it reached away from the river, being in Queenstown limestone. In shafts Nos. 1 and 2 water was met with, the average flow in shaft No. 1 reaching 800 gallons a minute, and 600 gallons a minute was found in shaft 2, but none was met with in shaft No. 1 below 105 ft. depth and in shaft No. 2 below 70 ft. depth. This water was readily disposed of by pumps, and none was found in the tunnel excavation proper, which remained perfectly dry.

The work of rock excavation, the average height of which throughout the tunnel was 26 ft., was pushed on three different benches, the top bench, 9 ft. high to the top of the arch, being always extended ahead of the second bench, 8 ft. high, the workmen in the latter bench being covered by a skeleton flooring over which the material excavated from the top bench was conveyed backward on small dump cars. The excavation of the bottom bench, which measured 9 ft. vertically to the bottom of the invert, was not commenced until the work on the other two benches had been nearly completed. Three 18 by 30 in. air compressors were employed, working 25 Little Giant 3½ drills, rack-a-rock being used in the wet shaft work, and a special tunnel forcite in the remainder. The force employed averaged 750 men, working in two shifts of ten hours each a day. The rapidity with which the rock cutting was effected, after the work was well under way, is something remarkable in the history of such enterprises, 338 ft. of tunnel, averaging 14 yards to the running foot, having been excavated in 26½ days. Messrs. Rodgers & Clement, engineers and contractors, who have the contract for the tunnel work, under the Cataract Construction Company, expect that all this portion of the work will be done before the middle of the summer. Of the Cataract Construction Company, Albert H. Porter is the engineer; Coleman Sellers and John Bogart, consulting engineers; Clemens Herschel, hydraulic engineer; and George B. Burbank, resident consulting engineer.

All of the factory buildings on the company's ground above the head of the tunnel will be more than a mile away from the falls, so that they will in no way take from the attractiveness of Niagara for visitors. The general plan of the main supply canal includes a lower reach 200 ft. wide, extending 1,200 feet inwardly from the river, thence parallel to the river in an up-stream direction for nearly 5,000 ft. where an upper reach 500 ft. wide connects this end with the river. Work on the lower reach only has been pushed thus far, but when all are completed the different sections will be separated by gate houses, so that the water can be drawn off in the usual way to facilitate repairs, a floating boom being provided to keep out ice at the upper end. On the lower reach of the main canal are to be located works intended to be run without intermission, and drawing their water outside of the gate houses separating this portion from the rest of the system. On this portion, nearest the river, will be located an extensive establishment of the Soo Paper Company, manufacturing also the wood pulp. This company is arranging to use 6,000 horse power, and has contracted for the construction of a wheel pit 16 × 50 ft. in size and a lateral tunnel 600 ft. long connecting the wheel pit with the main discharge tunnel. Farther back on the lower reach will be two central power stations, a design for one of which forms the principal picture on our first page, while on both sides of the main canal, for a distance extending more than half a mile back from the river, and over a mile in the direction of its course, the ground is laid out for mill sites and the necessary storage houses and other buildings required in manufacturing, as well as for the accommodation of the large population which will have to be provided for.

The best kind of turbine to use, and the method of setting the wheel, as well as the most effective means of transmitting and distributing the power obtained, have each been subjects concerning which the company has endeavored to make the most exhaustive investigations, but in relation to each of them there are still some features which have not yet been finally decided upon. It has, however, been practically determined that, in order to lessen the wear on the bearings of the wheel shaft, the water is to be admitted to the wheel on its under side, the shaft being of large size and hollow, and being journaled at its upper end in a thrust box to allow for any vertical movement. Mr. Edward D. Adams, President of the Construction Company, and Mr. Coleman Sellers visited Europe to examine into systems employed abroad for transmitting power, the advice of Sir William Thomson and others was obtained, and prizes were offered for plans and estimates as to the generation of power by turbines or other water motors, and for the transmission of the power to factories on the lands of the company and to a wider area. A number of systems were considered for the transmission of power by electricity and by compressed air. One prize of £500 was divided between two firms of Geneva, Switzerland, Messrs. Fuesch & Piccard and Messrs. Cuenod Sautter & Co., who acted in association. Several third prizes of £200 each were given as follows: Messrs. Hillairet & Bouvier, Paris; M. Victor Popp, of Paris, and Professor Reidler, of Berlin; Messrs. Vigreux & Levy, Paris; the Pelton Water Wheel Company, San Francisco; and the Norwalk Iron Works Company, of Norwalk, Connecticut.

The two firms receiving the largest prize produced two complete projects of similar character for the hydraulic utilization of 125,000 horse power, and its distribution electrically both to Cataract City—the name of the new town springing up on the lands of the company—and to Buffalo. The general features of both projects are the adoption of Girard or impulse turbines, with complete admission and back vanes, permitting the use of suction pipes, so that the fall below the turbines is not wasted; a unit of power of 2,500 horses for each turbine, as the maximum size which it is practically prudent to construct, and as capable of convenient arrangement to give the speed of rotation most suitable for the dynamos; in the electrical distribution, the adoption of continuous currents at constant potential, on the ground that that method has proved in practice safe, easy and simple. The method of continuous currents is preferred as being simpler, exacting less apparatus, and permitting the attainment of a high efficiency. The method of constant potential is preferred to constant current, because in the latter plan the intensity of current would be too great for one circuit, and several circuits would involve complications. As to the greatest power of a single dynamo machine, 1,250 horse power has been favored in one project, and 2,500 horse power in another.

The company has not determined to adopt any of the plans so far, except in a tentative way. A certain proportion of the power will be sold to mills controlling their own wheels, and delivering water into the tunnel, but at the central station the designs are at present limited to the generation of about 5,000 horse power by compressed air, another one of 5,000 horse power by electricity, with the possible extension of either one of these to the amount of 100,000 horse power, added in units of 2,500 to 5,000 horse power to either, one by one, in whichever direction proves the most profitable and is called for by the manufacturers. The company is anxious to do this work cautiously, economically, and thoroughly, so as to avoid mistakes. With this intent the matter has been placed in the hands of a board of engineers, of which Dr. Coleman Sellers is chairman and Colonel Turrettini foreign consulting engineer.

It is now the expectation of the company to make its first large contract for the delivery of power at a distance from the falls, with the city of Buffalo, 3,000 horse power being required for the lighting of the city. The present cost of a steam horse power in Buffalo is put at $35 per year, and the company offers to contract to furnish power on its grounds at the falls according to the following scale: For 5,000 horse power, $10 per horse power; for 4,500, $10.50; for 4,000, $11; and so on down to 300 horse power, for which there will be charged $21 per horse power per annum, each power to be supplied for twenty-four hour days. It is evident, therefore, that if the cost of transmission be within present expectations, the company will be able to furnish power at Buffalo at a much lower price than it is at present to be had at, and for a far larger field of usefulness than the mere lighting of the city. According to the most successful of all the recent efforts in the way of practically transmitting power electrically for a considerable distance, only about twenty-five per cent of the power was lost in transmitting it by wire a distance of 108 miles. This degree of success was attained at the recent Frankfort exposition. And if power can be at present so supplied for a distance of 100 miles from Niagara, it would be but a rash judgment which would undertake to say that it might not be also, in the very near future, similarly brought as far as New York City, in a way to be utilized at far less expense than the present cost of steam power. It is expected that the company will be entirely ready to furnish power, to those arranging for its use by taking water from their canals and discharging it into the tunnel, by October next, their first contract calling for the ability to turn wheels by this time.