taking that as the dividend, if we can determine the annual rate at which the falls recede, and take that for the divisor, our quotient will represent the time that has elapsed since the glacial period. The accompanying map gives a more definite idea of that divisor than we have ever before had. The lower dotted line represents the margin of the horse-shoe fall as mapped by the New-York geological survey in 1841, under the direction of Professor James Hall. The upper line is that made in 1875 for the U.S. geodetic survey. By comparing the two, a pretty correct calculation may be made as to the amount of recession of the horseshoe fall in the interval of thirty-four years. This cannot vary much from a hundred feet upon the whole line, being, as the commissioners calculate, two hundred and seventy feet at certain points.

Until this last survey, the attempts to estimate the time required for the cataract to recede from Queenston to its present position have been based upon very insufficient data. Mr. Bakewell, an eminent English geologist, gave personal attention to the problem as early as 1830, and, from every thing he could learn at that time, estimated that the falls had receded about a hundred and twenty feet in the forty years preceding. He recurred to the problem again in 1846, 1851, 1856 (*American journal of science*, January, 1857, pp. 87, 93), and was each time confirmed in the belief that the apex of the horseshoe fall was receding, on an average, three feet a year. On the other hand, Sir Charles Lyell, upon his first visit, in 1841, 'conceived' (upon what basis he does not tell us), that, at the utmost, the rate could not be more than one foot a year, which would give us thirty-five thousand years as the minimum time. But, as it appears, the result of the recent survey is to confirm the estimate of Mr. Bakewell, thus bringing the period down to about seven thousand years.

Two elements of uncertainty, however, tending to lengthen the estimate, should be noticed. In the first place, the recession may have been somewhat slower while the hard stratum, No. 3, was exposed. In the second place, the deposits of gravel running southward from St. David's, and corresponding to the lake-ridges, indicate that subsequent to the glacial period this whole region was slightly submerged beneath a shallow body of water; in which case, the recession of the gorge would have begun only upon the emergence of the land. And we have no means of telling how long an interval may have elapsed between the withdrawal of the ice and the withdrawal of the water.

On the other hand, it is probable that the channel of the preglacial stream extended somewhat above the whirlpool, thus reducing amount of work done since glacial time.

The above estimates are confirmed, also, by the small amount of change that has taken place in the species of animals during that period. The mollusks found in the river above the falls at the present time, are identical species with the shells found in the deserted river-channel at the top of the escarpment opposite the whirlpool, while nearer the falls the bones of the mastodon have been found in the same deposits; all which corresponds with a vast amount of other evidence, going to show that the present species are, in the main, identical with those existing at the close of the glacial period. The theory of evolution is relieved from a heavy burden by supposing a recent date for the close of the glacial epoch; for the changes since that epoch have been so slight, that the time allowed by the physicists is insufficient for the whole development of organic forms, unless the rate of change is more rapid than must be the case if the glacial period is thrown very far back.

G. FREDERICK WRIGHT.

NIAGARA FALLS CONSIDERED AS A SOURCE OF ELECTRICAL ENERGY.

THE first suggestion of the possible employment of Niagara Falls as a source of electrical energy, and the distribution of this energy in the shape of light and power, is due to C. W. Siemens. It was a large suggestion; and it took root speedily in what may be termed 'cosmical minds.' The way, however, to its fulfilment, has not been made plain to business enterprise. The most noteworthy remarks upon the subject were made by Sir William Thomson in 1881, at the York meeting of the British association. His remarks and calculations were in substance as follows: With the idea of bringing the energy of Niagara Falls to Montreal, Boston, New York, and Philadelphia, a total electromotive force produced by the dynamo-machines at the falls was taken at 80,000 volts. This was between a good earth connection at the falls, and one end of a solid copper wire of half an inch in diameter, and three hundred statute miles in length. The resistance of the circuit was so arranged that there should be an electromotive force of 64,000 volts at the remote end, between the wire and the earth connection. The calculations showed that a current of 240 webers would be produced in the wire, which would take energy from the Niagara end at the rate of 26,250-horse power, and only 5,250-horse power would be lost by the generation and dissipation of heat through the conductors; and thus 21,000-horse power would be available at the cities above mentioned. According to Sir William Thomson's calculation, it will be seen that eighty per cent of the energy would be thus transmitted. He also supposed that the solid copper wire was supported, like the ordinary telegraph-wire, upon poles, and found that an electric spark would not be produced between wires electrified to the difference of potential of 80,000 volts, unless they were within three-quarters of an inch apart: there could not be, therefore, great difficulty in the insulation. The cost of the copper conductor was reckoned at $185,000; and the interest upon this at five per cent is $9,500 a year.

At the time these remarks were made, great hopes had been excited by the invention of the Faure storage-battery; and Sir William Thomson closed his address by a glowing picture of the possibility of keeping a Faure battery of 40,000 cells constantly charged, we will say in New York, and applying a methodical system of removing sets of 50, and placing them upon local supply-circuits, while sets of 50 are replaced upon the main conductor.

The electromotive force of a Faure cell is in the neighborhood of 2 volts; and 50 cells would give 100 volts, which would be sufficient to supply several arc-lights. Thus the great electromotive force of 80,000 volts could be subdivided. Unfortunately, however, it has been found that the Faure battery is not permanent, or even fairly so. It can be said, without exaggeration, that its working-life is less than a year, and during the time of its best estate it cannot be depended upon. Many attempts have been made to perfect the Faure cell, and other forms of electrical accumulators; but no form of storage-battery is a commercial success at this present writing. It is not, however, beyond the power of invention to devise a system of what are called step-down dynamo-machines, by means of which the great difference of potential of 80,000 volts can be subdivided and utilized on different circuits. A number of small dynamo-machines could be connected with the great copper conductor leading to Niagara Falls in such a manner that the energy transmitted by this conductor could be distributed over a large extent of territory, either in the shape of light or power.

The distribution of light from a great central station has already been accomplished. The system of village-lighting devised by Edison can now be studied by those who are interested in the employment of the energy of Niagara Falls for a similar purpose. The limitations of distance apply to the present central electric-lighting stations; and those who are sceptical in regard to the great plan of utilizing Niagara Falls as a source of energy make a strong point when they ask why the system of great central stations has not been rapidly increased. It is true that abundance of water-power takes the place of coal; but the cost of the long conductors, the maintenance of the insulation, and the interest on the cost of any method of subdivision, must also be considered, and may be found to offset the cheapness of the source of the energy. We imagine, moreover, that few towns or cities would be willing to depend for their light on a seat of energy so remote as even fifty miles, to say nothing of three hundred. An accident to the copper conductor, due to the falling of a tree, or to some mischievous action, could plunge a city into darkness. If the conductor were placed underground, defective insulation would enter, and produce the same result. Even if the system of utilizing Niagara Falls as a source of electrical energy should be adopted, a supplementary system of lighting would have to be maintained in every city.

It is not safe to assume, that, if this large scheme of utilizing Niagara Falls could be made successful, business enterprise would already have moved in this direction; for capital, it is well known, is extremely conservative. The true reason that large sources of water-power have not been utilized for electric lighting on a large scale, is due to the fact that the small details, and what are called the small items, assume great proportions, and bid fair to consume all profits which come from a saving of coal. Thus the city of Buffalo could have been lighted by the utilization of the water-power along Niagara River; and we cannot believe that the failure to do so has been due either to the opposition of the gas companies, or to the lack of imagination of capitalists. In short, the facility with which energy in the shape of coal can be transported from place to place counterbalances at present the cheapness of a very remote source of energy in the shape of a waterfall.

The reasons for and against the utilization of the energy of Niagara Falls as a source of light apply also to the question of the electrical transmission of power, with this exception, that the electrical transmission of power has not reached even the perfection which systems of electrical lighting have attained.

JOHN TROWBRIDGE.

DR. GOULD'S WORK AT THE CORDOBA OBSERVATORY.

[THE Boston papers of last week Thursday gave a full account of the complimentary dinner given to Dr. Benjamin A. Gould on his return to this country, after the completion of his long series of observations in the Argentine Republic. We place before our readers that portion of the address made by Dr. Gould after the dinner, which narrates the history of his undertaking, on which he has expended nearly fifteen years. Want of space prevents our giving the introductory remarks in response to the warm welcome which he received from his hosts, or the many other excellent addresses upon the occasion.]

The undertaking began, as you know, with the project of a private astronomical expedition, for which my friends in Boston and vicinity had promised the pecuniary means. The selection of Cordoba as an especially desirable place was chiefly due to our lamented countryman, Gilliss, whose astronomical mission to Santiago de Chile had resulted in extensive and valuable observations of southern stars, and in the establishment of a national observatory, while it had enabled him to form a sound judgment as to the relative advantages of different points in South America for astronomical purposes, notwithstanding the total want of trustworthy meteorological data. This choice of place was confirmed by the counsel of the Argentine minister to this country. That minister was Sarmiento, a man who needs no encomium here; for during his brief residence in the United States he gained an exceptional number of friends and admirers. He transmitted to his government, then under the presidency of Gen. Mitre, my application for certain privileges and assurances, all of which were at once cordially conceded; but his interest in the plan became furthermore so great, that when, soon afterwards, he was himself elected president, he obtained the assent of the Argentine congress to the establishment of a national observatory, and wrote asking me to change my plans accordingly. The official invitation was sent in due time by the minister of public instruction, Dr. Avellaneda. The government assumed the expense of the instruments and equipments already bespoken, and authorized the engagement of the requisite assistants.

In 1874 Dr. Avellaneda succeeded Sarmiento in the presidency, and in 1880 he was himself succeeded by Gen. Roca. Thus four successive administrations have encouraged and sustained the undertaking; and notwithstanding the high political excitement which often prevails, and might easily have disinclined the members of any one party to give cordial aid to institutions established or fostered by their opponents, there has never been wanting a spirit of decided friendliness to the observatory, and to the scientific interests which have been developed under its auspices. No president of the nation, and no minister of the department under which the observatory is placed, has failed to give strong practical evidence of his good will. There has been none of them to whom I do not owe a debt of gratitude. I have never made an official request which has not been granted, and in such a way as to enhance the favor. And just as the official founders of the observatory met us with a cordial welcome on our arrival, so the government of to-day has overwhelmed me with kindness, and tokens of regard, on my departure. On the very last evening before embarking, when it was my privilege to receive the farewells of a crowded assemblage in the halls of the Argentine geographical institute, and to hear words of sympathy and commendation from the lips of Gen. Sarmiento, my earliest Argentine friend, speaking in behalf of that society, I replied in the few words which alone were possible at the time, but with all sincerity and truthfulness, as follows: —

"It was you, sir, who provided the opportunity for which I was yearning: it was the Argentine Republic which made it easy for me to avail myself of it. It has been the national government which, in its various phases, and under so many different administrations, always provided all needful means and resources: it is the Argentine people which has accompanied me in my tasks, giving support by their sympathy, and incentive by their kindness."

The original purpose of the expedition was to make a thorough survey of the southern heavens by observations made in zones between the parallel of 30° and the polar circle; but the plan grew, under the influence of circumstances, until the scrutiny comprised the whole region from the tropic to within ten degrees of the pole, — somewhat more than fifty-seven degrees in width, instead of thirty-seven degrees. And although it was no part of the original design to perform all the numerical computations, and still less to bring the results into the form of a finished catalogue, it has been my exceptional privilege, unique in astronomical history so far as I am aware, to enjoy the means and opportunity for personally supervising all that vast labor, and to see the results published in their definite, permanent form. Of course this has required time. The three years which I had purposed devoting to the less complete work have been drawn out to nearly fifteen; and you will comprehend what that implies for one who loves the friends of his youth, his kindred, and his country. Yet even here there has been consolation. For, while the work has demanded all that period, it did not absorb the whole time, and opportunity was left for other studies. Among the astronomical ones, it has been possible to examine all the stars as bright as the seventh magnitude, up to 10° of north declination, for careful estimates of their respective brilliancy, and to reform the arrangement and boundaries of the southern constellations; also to carry out the observations and computations for another stellar catalogue, more exact than that of the zones, and extending over the whole southern hemisphere. The