over, as 180° in air is equal to 1.0 (since $n = 1.0$, and the sine of half 180° or 90° $= 1.0$), we see with equal readiness whether the aperture of the objective is smaller or larger than that corresponding to 180° in air.

Thus, suppose we desire to compare the relative apertures of three objectives, one a dry objective, the second a water-immersion, and the third an oil-immersion. These would be compared on the angular aperture view as, say, 74° air-angle, and 118° balsam-angle; so that a calculation must be worked out to arrive at a due appreciation of the actual relation between them. Applying, however, "numerical" aperture, which gives .60 for the dry objective, .90 for the water-immersion, and 1.30 for the oil-immersion, their relative apertures are immediately appreciated, and it is seen, for instance, that the aperture of the water-immersion is somewhat less than that of a dry objective of 180°, and that the aperture of the oil-immersion exceeds that of the latter by 30 .

When these considerations have been appreciated, the advantage possessed by immersion in comparison with dry objectives is no longer obscured. Instead of this advantage consisting merely in increased working distance or absence of correction-collar, it is seen that a wide-angled immersion objective has a larger aperture than a dry objective of the maximum angle of 180°; so that for any of the purposes for which aperture is desired, an immersion must necessarily be preferred to a dry objective.

The task of making an abstract of these papers was not a light one and we are indebted to the *English Mechanics* for the above résumé.

BOOKS RECEIVED.

DISCOVERY OF THE PREGLACIAL OUTLET OF THE BASIN OF LAKE ERIE INTO THAT OF LAKE ONTARIO; with notes on the Origin of our Lower Great Lakes. By PROF. J. W. SPENCER, B. A. Sc., Ph. D., F. G. S., Kings College, Windsor, N. S. 1881.

As one new branch of knowledge is raised to a science, there still seems to be some other rising to importance. For a long time the explanation of the Physical Features of America has been handed over to the rival Glacier and Iceberg theories, and though much good work has resulted, yet an almost unlimited amount of nonsense has been written, especially by the extreme or ultra-glacial school. During all these years comparatively little attention has been given to the subject of the river geology, more than that many buried channels have been recorded with but few attempts at the reduction of the abstract facts to a branch of Science. There has, however, been a very great difficulty, owing to the Preglacial valleys often being entirely obscured, or, if apparent, an absence of the knowledge of their depths has prevented generalization. In most of the cases recorded, the buried channels have not had courses greatly differing from those of modern times. It has been known for some time that the waters of most of the great lakes had southern outlets when at higher levels, and even to-day the drainage of Chicago passes to the Mississippi. It has been frequently suggested that Lake Ontario emptied by the Mohawk into the Hudson. This, however, was not the case. We are then compelled to place General G. K. Warren as the father of Fluviatile Geology, for he discovered that the Red River of the North (with Lake Winnipeg, the Saskatchewan, and other great rivers of the North West territories of Canada, as tributaries) discharged by the Minnesota river into the Mississippi, and thus produced a river to which no modern water is comparable. On further investigation Gen. Warren's views are found to require some modification, yet this does not detract from the position which may be fairly assigned to him. Dr. Newbury's observations in Ohio have also thrown much additional light on the subject, but a much more important work has been accomplished by Mr. J. F. Carll, of Pennsylvania, when from a careful study of the levels and borings for oil in that State, he discovered that the Upper Alleghany and several other rivers now flowing into the Ohio, formerly emptied into Lake Erie (or its basin).

But the most important contribution on the subject of Fluviatile Geology that has been made is the recent paper of the above title, by Professor Spencer, now of Kings College, Nova Scotia, but formerly residing in the lake region, in the Province of Ontario. The paper of the above title was read before the American Philosophical Society, of Philadelphia, and its publication will be found in the forthcoming proceedings of that Society. It is also being reprinted as an appendix to Report Q 4 of the Pennsylvania Survey, as shown by the maps which accompany the author's edition, of which we have just received a copy. The following is a synopsis of the principal points of the paper:

The Niagara escarpment bends abruptly at the western end of Lake Ontario, and has a height of about 500 feet above the lake. Through this limestone ridge the Dundas valley extends, and enters the extreme western end of the lake. At the narrowest portion of the valley the width is upwards of two miles, and the margins are those of the walls of a perfect *cañon*, 500 feet deep. But by boring near one of its margins, the buried channel is found to reach 227 feet below the surface of Lake Ontario, making a total depth of 743 feet, but with a computed depth in the central part of its course of not less than 1000 feet. The author first discovered that the ancient upper portion of the Grand River left its modern course south of Galt, and although a portion of the old bed is entirely obscured, yet by pursuing the course of the deep wells the ancient route can be traced through the drift to the western end of the Dundas *cañon* and Lake Ontario. In following up this subject Dr. Spencer discovered that the lower portion of the Grand River was formerly an outlet of the Erie basin, which discharged by a course from a point southward of Cayuga (Province of Ontario), and flowed to the westward of this town and entered the present valley, which is two miles wide and eighty feet deep, but underlaid deeply with drift. Westward of Seneca the ancient river left its modern course and passed into the Dundas valley. All these observations are elaborately worked out by levels, deep well borings, and deep ravines, with the one well in this course indicating a depth of 1000 feet of drift in the ancient valley, measuring from the limestone floor of the county.

The outlet of Lake Erie is directly opposite to that of the ancient Alleghany River.

Again, Dr. Spencer has made a study of the soundings of the lakes, and has discovered a long submerged escarpment extending along the southern side of Lake Ontario to near Oswego, at the foot of which the Ancient River from the Dundas Valley ran. The author has shown that an ancient, broad channel, extended from Lake Huron and entered Lake Erie between Port Stanley and Vienna, in the Canadian Province of Ontario. This channel has a marginal depth of 200 feet below Lake Erie, but with a probable depth sufficient to drain Lake Huron.

With regard to Lake Superior, Prof. Spencer shows that it formerly emptied into the northern end of Lake Michigan, and formed a river channel now represented by deep pot-holes. He brings forward some of the evidence showing that Lake Michigan emptied or was completely drained by the tributaries of the Mississippi, and that this lake was probably disconnected from Lake Huron. At the same time, he shows that Lake Superior (when it was at no higher level than at present) did not empty by the Green Bay and valley of the Fox and Wisconsin Rivers.

The author denies the hypothesis of the glacial origin of the Great Lakes, and brings forward strong evidence in support of his views. He correlates with his work and maps the buried channels discovered in Pennsylvania and

Ohio, the whole constituting the broadest study on the "Great River Age" that has been made. He considers the great lakes as largely valleys of subaërial erosion, traversed by the Grand River which he has worked out. The Ancient buried course of the Niagara, the author considers as interglacial, being formed and closed subsequent to the closing of the Dundas Valley. Of course, all this presupposes the action to have been going on when the continent was six hundred feet higher, and from the pot-holes in the New York Harbor, we know it to have had an altitude of at least 900 above the present elevation. To perfect the work there remains the discovery of the outlet of Lake Ontario, which was not by the Mohawk, as in its valley near Little Falls, it passes over hard rock. Yet Prof. Spencer insinuates, in this paper, that he is on the track of this discovery also, and that the study will be pursued during the coming summer. We wish the author every success, and if this ancient outlet be discovered, certainly he will have added much to his already most important discovery, and will fairly be considered as one of the founders of this new scientific development.

It must be further stated that the author does not consider all the ancient buried rivers now running southward, but formerly flowing northward, as having in any way been derived from glacier action, and more recently than the paper, which we are reviewing, a notice by him was read before the American Philosophical Society showing that the Monongahela flowed directly northward by the upper Ohio, Beaver, Mahoning and Grand Rivers of Ohio (the last three reversed in Preglacial times) to Lake Erie, thus adding another important tributary to the Erie Basin and further changing the physical features of the Continent.

This paper, which is the first preliminary notice of his work on the Great River Age, will do much to draw attention to the interesting subject which is destined to have an equal place with Glacial Geology, with the extreme views of which it will be found to conflict more or less.

ON M. C. FAURE'S SECONDARY BATTERY.

The researches of M. Gaston Planté on the polarization of voltameters led to his invention of the secondary cell, composed of two strips of lead immersed in acidulated water. These cells accumulate and, so to speak, store up the electricity passed into them from some outside generator. When the two electrodes are connected with any source of electricity the surfaces of the two strips of lead undergo certain modifications. Thus, the positive pole retains oxygen and becomes covered with a thin coating of peroxide of lead, while the negative pole becomes reduced to a clean metallic state.

Now, if the secondary cell is separated from the primary one, we have a veritable voltaic battery, for the symmetry of the poles is upset, and one is ready to give up oxygen and the other eager to receive it. When the poles are connected, an intense electric current is obtained, but it is of short duration. Such a cell, having half a square metre of surface, can store up enough electricity to keep a platinum wire 1 millim. in diameter and 8 centims. long, red-hot for ten minutes. M. Planté has succeeded in increasing the duration of the current by alternately charging and discharging the cell, so as alternately to form layers of reduced metal and peroxide of lead on the surface of the strip. It was seen that this cell would afford an excellent means for the conveyance of electricity from place to place, the great drawback, however, being that the storing capacity was not sufficient as compared with the weight and size of the cell. This difficulty has now been overcome by M. Faure: the cell as he has improved it is made in the following manner:

The two strips of lead are separately covered with minium or some other insoluble oxide of lead, then covered with an envelope of felt, firmly attached by rivets of lead. These two electrodes are then placed near each other in water acidulated with sulphuric acid, as in the Planté cell. The cell is then attached to a battery so as to allow a current of electricity to pass through it, and the minium is thereby reduced to metallic spongy lead on the negative pole, and oxidised to peroxide of lead on the positive pole; when the cell is discharged the reduced lead becomes oxidised, and the peroxide of lead is reduced until the cell becomes inert.

The improvement consists, as will be seen, in substituting for strips of lead masses of spongy lead; for, in the Planté cell, the action is restricted to the surface, while in Faure's modification the action is almost unlimited. A battery composed of Faure's cells, and weighing 150 lbs., is capable of storing up a quantity of electricity equivalent to one-horse power during one hour, and calculations based on facts on thermal chemistry shows that this weight could be greatly decreased. A battery of 24 cells, each weighing 14 lbs., will keep a strip of platinum ⅝ths of an inch wide, 1-32nd of an inch thick, and 9 feet 10 ins. long, red hot for a long time.

The loss resulting from the charging and discharging of this battery is not great: for example, if a certain quantity of energy is expended in charging the cells, 80 per cent of that energy can be reproduced by the electricity resulting from the discharge of the cells; moreover, the battery can be carried from one place to another without injury. A battery was lately charged in Paris, then taken to Brussels, where it was used the next day without recharging. The cost is also said to be very low. A quantity of electricity can be produced, stored, and delivered at any distance within 3 miles of the works for 1½d. Therefore these batteries may become useful in producing the electric light in private houses. A 1250 horse-power engine, working dynamo machines giving a continuous current, will in one hour produce 1000 horse-power of effective electricity, that is to say 80 per cent of the initial force. The cost of the machines, establishment, and construction will not be more than £40,000, and the quantity of coal burnt will be 2 lbs. per hour per effective horse-power, which will cost (say) ½d. The apparatus necessary to store up the force of 1000 horses for twenty-four hours will cost £48,000, and will weigh 1500 tons. This price and these weights may become much less after a time. The expense for wages and repairs will be less than ¼d. per hour per horse-power, which would be £24 per day, or £8800 a year; thus the total cost of one-horse-power for an hour stored up at the works is ¾d. Allowing that the carriage will cost as much as the production and storing, we have what is stated above, viz., that the total cost within 3 miles of the works is 1½d. per horse-power per hour. This quantity of electricity will produce a light, according to the amount of division, equivalent to from 5 to 30 gas burners, which is much cheaper than gas.—*Chemical News.*

MICROSCOPY.

We offer the following notes culled from the pages of the *Journal of the Royal Microscopic Society*:—

A singular species of Ncarus is described by A. D. Michael, found by him at Land's End, England. It belongs to the genus *Dermaleichus* (Koch) *Analges* (Nitsch) but does not fit into any of the five genera, or sub-genera, into which Robins has divided the group. The leading feature in this curious creature was that the male had the left leg of the second pair conspicuously larger than its fellow on the right side, had a totally different tarsus, and supported by a different and more powerful epimeral and sternal arrangement. This deformity makes this species entirely different to any other *Ncarus.*

Haustein has observed in the central cells of *chara,* chlorophyll-bodies containing starch which could not be regarded as the product of assimilation. C. Dehnecke has now investigated a number of similar instances, in which the starch contained within the chlorophyll-grains appears not to serve the purpose of immediate assimilation, but to be stored up as a reserve material.

A new stereoscopic eye piece has been arranged by Professor E. Abbe. The special feature of this instrument