combination whatever of natural bodies to derive an unlimited amount of mechanical force [energy], or on the assumption that all actions in nature can be ultimately referred to attractive or repulsive forces, the intensity of which depends solely upon the distances between the points by which the forces are exerted." He showed also that it was immaterial which of these maxims was assumed, as the other could be at once obtained from it. How by the aid of either of these hypotheses we pass from the equation given above to the law of the conservation of energy is of course well known. The point to which it seems necessary to draw attention is that some hypothesis is required, and that either of these is sufficient for the purpose.

As the second of Helmholtz's maxims is simply an extension of the third law of motion, and as Newton's three laws have obtained such wide usage, it would seem to be desirable to adopt the second maxim as a fourth law of motion. Were we to select the first maxim, it would be necessary to re-cast our fundamental hypotheses altogether.[1] Possibly it might be advantageous to take this course, to make, as Tait[2] suggests, the laws of the conservation and the transformation of energy our fundamental hypotheses, and to banish the conception of force to the limbo of once useful things. But if Newton's laws are to be retained, they should be supplemented by the second of Helmholtz's assumptions.

It is at once obvious that this fourth law will, like the third, be independent of points of reference; and it follows that the law of the conservation of energy will hold relatively to all points by reference to which the second law holds. This conclusion is inconsistent with Newcomb's assertion[3] that this law "assumes that we refer the motions of all the bodies whose energy is considered to some foreign body of infinite mass, from which emanate the forces which give motion to the system." According to the above, this law may of course be expressed relatively to a particle of infinite mass, and, if thus expressed, the forces which give motion to the system may be supposed to emanate from that particle. But it may also be expressed relatively either to a particle of finite mass free from the action of force, or to the centre of mass of the system itself whose energy is conserved.

4. Reduction of the Laws of Motion.

Finally, the four laws of motion may obviously be reduced to two. The first has already been seen to be a particular case of the second. The third is involved in the fourth; for when it is asserted that natural forces are attractions or repulsions, it is implied that their action and reaction are in opposite directions, and when it is asserted that they may be expressed as functions of the distances of the particles between which they act, it is implied that their action and reaction are equal. The four laws thus reduce to two, which may be enunciated somewhat as follows:—

The Law of Force. — Relatively to any particle free from the action of force, the acceleration produced in another particle by a force is proportional to the force and has the same direction.

The Law of Stress. — Natural forces may be considered to be attractions or repulsions whose magnitudes vary solely with the distances of the particles between which they act.

[1] Many writers illogically select the first maxim as a fourth law. See Professor Johnson's paper cited above; also my Kinematics and Dynamics, § 436.

[2] Ency. Brit., 9th Ed., Art. Mechanics, § 291.

[3] Phil. Mag., Ser. 5, Vol xxvii. (1889), p. 116.

THE GREAT LAKE BASINS.

BY P. J. FARNSWORTH.

THE problem of the origin of the Great Lakes has for a long time engaged the attention of the scientists, who have come to a variety of conclusions, none of them very satisfactory. Subsidence, ice action, glacial scooping, and President Chamberlin's theory that they were hollows made by accumulating ice bending down the earth's crust.

An article in *Science* of June 3 presents a more plausible theory, that they are vallies of erosion, made by some great river, giving as evidence the map of Dr. Spencer, pointing out the discoveries and probable deep pre-glacial channels leading into the St. Lawrence and the Atlantic. Professor Spencer, in his paper on High Continental Elevations, read at the Scientific Association at Toronto, 1889, sums up by saying, "The lake basins are merely closed-up portions of the ancient St. Lawrence valley and its tributaries." "The lake basins are all excavated out of Palæozoic rocks except a part of that of Lake Superior."

If we go back in geologic history to Azoic times we find that the first emergence of the continent was the V-shaped land around Hudson's Bay, an open sea below it. Next, an emergence of a point below the V and a line of height extending along the lower side of what we call the river and gulf of St. Lawrence. A sea or strait extended round the primitive land from the Atlantic to the Arctic Ocean on the north-west. After the elevation of the trough at the north-west, an inland sea was left covering Superior, Michigan, Huron, and Ontario, leading into the St. Lawrence Gulf. In time there was elevation and subsidence and flexion of strata, as pointed out by Professor Spencer, and the great basins were left as interior seas. There was a large water-shed to the north that compelled an overflow, that made its way in the deep channels that have been discovered, at some time out of Ontario, across New York, then, if there was continental elevation, making the deep channels down the valley of the St. Lawrence and far out into the Gulf. Lake Champlain was a pool in a fissure of the Azoac world, that was connected with the open channel in the Archean land.

The ice period so obstructed the old outlet that when it was melting, the superfluous waters of the great basins were poured into the Gulf of Mexico through the Illinois and Wabash rivers. When the ice disappeared, the old outlet had become obstructed by flexions of strata and mountains of drift. It is evident that Lake Michigan had a channel through Georgian Bay, and thence into Ontario. It is not yet apparent where the deep channel for the waters of Superior came in, or that it had any such. It has an insignificant but sufficient outlet through the St. Mary's River. Michigan and Huron reach Ontario over the St. Clair flats and through the shallow trough that holds Lake Erie, which probably is of post-glacial age, and then into Ontario down the hill that is being cut back by the falls of Niagara.

The great lakes were deep seas before the world was cold enough for ice, and were great basins before glaciers were possible.

One could hardly conceive how glacial ploughing coming from the north or north-east could make chasms at such angles to each other. In regard to cut of channels of erosion, it would require a river from the south-west and north-west, from Michigan and Superior, of such magnitude that great valleys or traces of them would be left. Lake Superior is 360 miles long and 150 miles wide in some places, with a

depth of 1000 feet, with a probable 100 or 200 feet more covered with sediment 600 feet above tide-water, which would make its bottom 500 feet below sea-level. To conceive it as an old river channel would require an elevation of the continent of 1500 feet above its present level. It is, moreover, surrounded by high rocky shores having few rivers coming into it, as its watershed was never large and not channeled by fjords.

There may have been an elevation of the continent, but the lakes went up with it; there was undoubtedly ice but the lakes were there before it. They are pools left by the old Azoic Sea.

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NOTES AND NEWS.

IN the latest quarterly statement of the Palestine Exploration Fund as we learn from *Nature*, it is said that considerable progress is being made with the Akka-Damascus Railway, the route of which, after various expensive surveys, has been definitely decided upon. The line chosen is practically that first suggested by Major Conder, R.E. several years ago. Beginning at the great fortress of Acre, the railway will run down the plain of Acre parallel with the sea, throwing out a branch to Haifa, at the northern foot of Mount Carmel, and thence to and across the plain of Esdraelon, passing near Nazareth to Shunem and Jezreel, and through the valley of Jezreel, skirting the slope of the hills, to the river Jordan, which will be crossed within sight of Bethshean. The Jordan here offers exceptional facilities for the erection of the railway bridge, consisting of two spans. Not only are the two opposite banks of the river formed of solid rock, but the centre of the river contains a large block of similar rock, from which each span of the bridge will be thrown to the east and west bank respectively. From the Jordan the railway will ascend the slope of the Jaulan Plateau, along the crests that close the eastern shores of the Sea of Galilee, this ascent constituting the only difficult portion of the line, but which the surveys now made show to be much easier of accomplishment than was originally anticipated. The plateau near El'Al being reached, an easy gradient will carry the line by Seil Nawa and Kesweh to Damascus. Passing through the finest plains of western and eastern Palestine, the railway will be one of great importance. The authorities of the Palestine Exploration Fund are of opinion that its construction can hardly fail to lead to important archæological discoveries, and the committee hope to make arrangements for obtaining full information respecting these.

— The *Kew Bvlletin* for May and June, according to *Nature*, contains several contributions which will be of great interest to botanists and to various classes connected with the industrial applications of botany. One of these contributions is a valuable report (with a plate) by Mr. George Massee on a disease that has attacked vanilla plants in Seychelles. In the same number are printed the second of the Decades Kewenses Plantarum Novarum in Herbario Horti Regii Conservatarum, and the second decade of new orchids. An excellent illustration of the way in which the authorities at Kew seek to promote industry is afforded by a correspondence on Sansevieria fibre from Somali-land. The increased attention devoted to the production of white rope fibres in the western tropics appears to have had a stimulating effect in the East Indies, and now the production of fibre from *Agave vivipara* in Bombay and Manila is followed by a fibre obtained from Somaliland from a singular species of Sansevieria. This fibre was first received in this country as an "Aloe" fibre. It was soon noticed, however, that it possessed characteristics differing from all ordinary "Aloe" fibre, and a request was made to the Foreign Office that Colonel Stace should be invited to obtain for the Royal Gardens a small sample of the fibre, a large leaf from the plant yielding it, and, if possible, a few small plants for growing in the Kew collection. In due time the specimens arrived in excellent order, and it was found that the fibre is one of the many so-called Bowstring Hemps, and probably yielded by *Sansevieria Ehrenbergii*, a plant first collected by Dr. Schweinfürth. Little or nothing was known of it until it was described by Mr. J. J. Baker, F.R.S., in the Journal of the Linnean Society, Vol. xiv., p. 549. Its locality is there stated as "between Athara and the Red Sea." The plant is described in a letter to the Foreign Office, written by Mr. D. Morris, as a very interesting one, and he adds that its existence as a source of a valuable supply of fibre will be sure to awaken attention among commercial men in Great Britain. Messrs. Ide and Christie, writing to Mr. Morris, speak of the fibre as an excellent one of fair length and with plenty of "life." "In character," they say, "it strongly resembles the best Sisal hemp, with which we should have classed it but for your statement that it is derived from Sansevieria. With the exception of its color, its preparation is perfect, and, even as it is, we value it to day at £25 per ton. We are of opinion that if care were taken to improve the color a considerably higher price would be readily attainable, perhaps as much as £50 per ton, if a pure white fibre could be attained without loss of strength and lustre."

— The Harvey process of case-hardening, which has been so successfully applied to giving a hard surface to armor plates, is carried out as follows, according to *Engineering:* The plate to be treated is made out of mild steel, containing, say, 0.10 per cent to 0.35 per cent carbon, and, after being formed to its final shape, is laid flatwise upon a bed of finely-powdered dry clay or sand, which is deposited upon the bottom of a fire brick cell or compartment erected within the heating chamber of a suitable furnace. The upper surface of the plate is then covered with powdered carbonaceous material, which is tightly packed. Above this is a layer of sand, and over the sand is laid a heavy covering of fire-bricks. The furnace is then lighted and raised to a temperature sufficient to melt cast-iron, and this heat is maintained for a greater or lesser period, according to the amount of carbonizing to be effected. About 120 hours are said to be required for a plate 10½ inches thick. On removal from the furnace such a plate is found to have had the composition of its upper surface changed. At a depth of about 3 inches from this surface the percentage of carbon has been raised by about 0.1 per cent, which increases progressively as the outer surface is neared, when the amount of carbon may rise to 1 per cent. It is said that this process, though, as will be seen, it resembles the ordinary cementation process, does not cause any blistering of the surface of the plate. This the inventor attributes to the high temperature at which it is carried out; but it is also suggested that the absence of blisters may be due to the homogeneity of the metal used, which, unlike the wrought-iron bars used in the cementation process, is free from cinders.

— An interesting addition to the much-vexed Sumero-Akkadian question has recently been made by an Ottoman scholar. Ohannes Sakissian Effendi, an official in the Treasury department at Constantinople, has issued privately the first instalment of a work intended to prove that the non-Semitic idiom of the cuneiform inscription is related linguistically to Armenian, Turkish, and ancient Egyptian. He strenuously combats the theory of the Rev. C. J. Ball, of the affinity of Akkadian and Chinese. That Akkadian or rather Sumerian was related to Turkish or to Armenian is by no means inherently improbable. We can hardly admit being convinced by the author as yet, and would prefer awaiting some ethnologic evidence before reaching a conclusion. But we cannot fail to welcome to the ranks of students of the ancient civilization of Mesopotamia the first subject of the Empire of which Mesopotamia is a part, who has busied himself with cuneiform studies. Turkey has produced investigators in all branches of modern science, a classical archæologist and explorer like Hamdi Bey, a Turkish lexicographer like the late Ahmed Vefik Pacha, or a man like Tewfik Bey Ebuzzia, the historian of Turkish literature, a writer on military matters like Djeva Pasha, the present Grand Vizier, or a student of pure mathematics like Tewfik Pasha, the present minister of public works. Sakissian Effendi is the first Ottoman who, to our knowledge, has written on a subject connected with cuneiform research, and we take the appearance of his brochure as an omen that these studies will be seriously taken up at the Imperial Museum in Constantinople. A catalogue of the cuneiform objects preserved in that museum would be eagerly welcomed by the learned world.