Mr. R. G. Haliburton read a paper on the dwarf races of the New World.

Rev. W. H. Beauchamp described the southern visit of the Eskimo, in which he declared that evidence of Eskimo contact with the Indians of Northern New York were to be found in certain stone knives found among them, specimens of which he exhibited.

Mr. Dorsey read a paper by William Sturtevant, in which Mr. Sturtevant described three ears of corn from prehistoric grains from localities in Peru, collected by Mr. Dorsey, the especial point of interest being that from a grave of undoubted antiquity in Iquique was found a kind of corn which was commonly supposed to be of a recent cultivated variety. Mr. Dorsey called attention to the great importance of collecting and preserving all varieties of corn from all prehistoric sources as a means of determining the original habitat of the maize, as well as furnishing an index of civilisation.

THE DISPLACEMENTS OF THE ROTATIONAL AXIS OF THE EARTH.[1]

DISPLACEMENTS of the rotational axis of the earth with reference to fixed directions in space have been observed since the earliest ages of astronomical measurement; for such displacements, visible in wanderings of the pole of the apparent diurnal rotation of the celestial sphere among the constellations of fixed stars, exist in such enormous amplitudes, that in their main features they could be detected by the aid of very simple apparatus and observations.

The true law and explanation of these wanderings of the pole remained, nevertheless, a deep mystery till Copernicus lifted the veil by showing that they were only the celestial image of real displacements of the rotational axis of the earth in space, and until Newton came and, combining his discovery of universal gravitation with his deduction of the ellipsoidal figure of the earth, proved that these displacements are due to the actions of the moon and the sun on the earth.

The mathematicians of the eighteenth century completed this explanation by profound researches embracing the full theory of free rotation of a solid system of masses, under the action of various disturbing influences, not only those acting from outwards on the rotating body (as in the case of the sun's and the moon's attractions on the earth), but also those depending upon the condition or changes within the rotating system itself.

Among several interesting results, these investigations pointed out an essential difference between the development of the disturbed rotation in the first and in the second case.

Upon the supposition, corresponding to the real terrestrial conditions of the problem, namely, that all the disturbing influences are relatively small in comparison with the amount of energy represented by the primary rotation of the earth itself, the following distinctions were demonstrated.

Exterior disturbing influences will mainly produce displacements of the axis in space, and corresponding wanderings of the pole among the stars, whilst the simultaneous displacements of the axis in the earth itself, in consequence of the particular conditions of their evolution, remain insensible.

On the contrary, interior conditions and disturbing influences, as those contained in the configurations of the masses, or in changes of the distribution of the masses composing the rotating system, will mainly produce displacements of the rotational axis in the rotating body itself, whilst in this case the simultaneous displacements of this axis in space and the corresponding variations of the position of the pole among the stars remain insensible.

Very soon after these deductions had been made from the theory, astronomers began to inquire if also effects of the latter type, that is to say, displacements of the rotational axis in the earth, really existed.

According to the theory, such displacements ought even then to exist when the distribution of the masses composing the earth is not in the slightest degree variable.

It is sufficient for producing such displacements that the position of the rotational axis of the earth is actually not in perfect coincidence with one of its principal axes of inertia, known as the principal axis.

[1] A paper read by Prof. W. Foerster, Director of the Royal Observatory of Berlin, before the British Association.

The slightest deviation of the rotational axis from the principal axis has the consequence that the pole of the rotational axis begins and continues to describe a small circle around the pole of the principal axis.

The velocity of this movement depends upon the law of the figure and of the distribution of the masses composing the earth, and the best numerical data for this dependence had given the result that the displacement in question would probably have a period of nearly ten months.

Now all such displacements, possibly measurable with reference to fixed directions in the earth, and insensible with reference to fixed directions in space, could be found in the most favourable way by measuring as exactly and continuously as possible the distance of the pole from the zenith of the observer's station; in other words, by repeated determinations of the geographical latitudes. But, notwithstanding very long and refined determinations of the geographical latitudes at some of the principal observatories, beginning shortly before the middle of the present century, only very uncertain and discordant traces of the phenomena in question were found.

The reason for this want of success is now very clear. Astronomers had limited their researches too narrowly to the last-mentioned type, namely, to the supposed regular ten-monthly periodical movement of the pole of the rotational axis around the pole of the principal axis. Too easily it had been admitted that all the existing variations of the distribution of terrestrial masses were by far too small for altering sensibly the position of this principal axis itself.

It was Lord Kelvin, at the Glasgow meeting of the British Association (1874), who at first drew the attention of the scientific world to the consideration of the great natural transports of masses of air and water and various masses by the water, going on continuously and periodically in the form of currents and circulations of different kind, as well in the atmosphere as in oceans and rivers, for instance the enormous periodical sediments of snow and ice. He showed that these very considerable variations of the distribution of masses on the earth could not only produce sensible displacements of the principal axis of inertia, but that such displacements of this axis could have an amplifying effect on the total amount of displacements of the rotational axis.

For if the principal axis were itself not in a constant position, the theoretically required movement of the rotational axis around the principal axis would become a very complicated movement, differing entirely from the simple form which to that epoch had appeared in the researches of astronomers.

This epicyclic character of the movement of the pole of the rotational axis could considerably modify not only the length of the period, but also the whole geometrical character and amplitude of the curve in such a way, that in longer periods epochs of very small variations of latitude could alternate with epochs of considerably increased variations of latitudes. Possibly, as a further consequence of this complication of the displacements of the two axes, and as a consequence of the still existing plastic state of certain parts of the earth, as well as by the damping effects of the fluid parts, even *progressive*—though very slow and unsteady progressive—displacements of the rotational axis in the earth could still result.

The field of this research was thus decisively cleared by the veritably releasing ideas of Lord Kelvin. Finally, about four years ago, by the co-operation of some observatories with the International Geodetic Union, clear evidence was obtained, and in the last three years, with the aid of an expedition sent by the International Union to Honolulu, decisive proofs of such displacements have been found. I consider it a special honour and pleasure to be enabled to submit some of the newest results of this international co-operation to a meeting of the same Association which, twenty years ago, had been witness of the almost prophetic assertions of one of its most illustrious members regarding the real conditions of this important phenomenon.

I have prepared a diagram (Fig. 1, p. 489) showing these newest results. You see in this diagram a representation of the wanderings of the pole of the rotational axis of the earth on the surface of the latter during the last twenty months, from October 1892 to May 1894.

This sketch is founded on nearly 6000 single determinations of latitude made in the Observatory of Kasan (Eastern Russia), Strassburg (Elsass), and Bethlehem (Pennsylvania). The observations are condensed in twenty monthly mean results,

numbered, as you see, from zero to nineteen. Every one of these resulting monthly positions of the pole indicated by the centres of the small circles is thus the mean result of about 300 single determinations.

The accompanying figure is drawn on a scale of two millimetres to one-hundredth of a second of arc, and the maximum amplitude of the curve is nearly 50-hundredths, or half a second. The amplitude of these movements of the pole on the surface of the earth is between 40 and 50 feet.

You see the general character of the movement quite in accordance with what has been mentioned concerning its complicated and somewhat spiral character. The sense of the motion is turning from west to east. The velocity is apparently very variable, and it seems as if we now approach an epoch in which the amplitude considerably diminishes. It is also evident that such

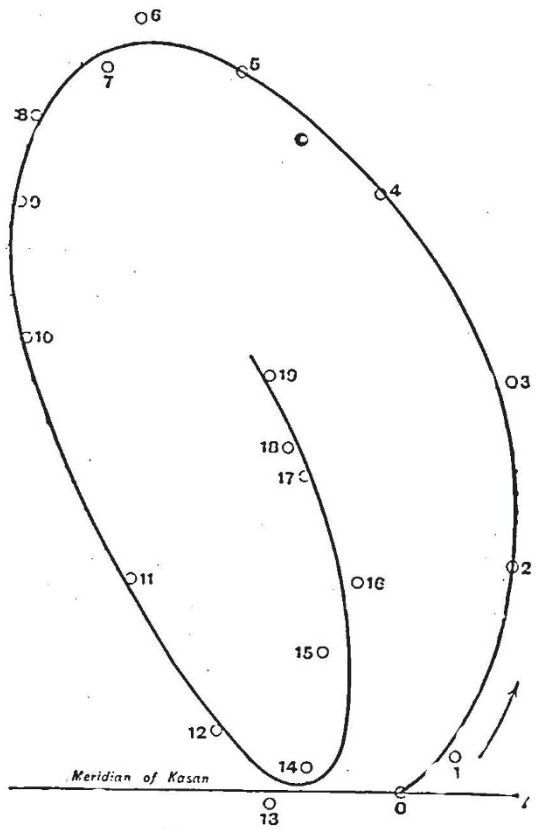

FIG. 1.—Movement of the North Pole of the rotational axis of the earth Derived from observations made at Bethlehem, Strassburg, and Kasan :—

0 = 1892 Oct 20	13 = 1893 Nov. 1.
1 = ,, Nov, 1.	14 = ,, Dec. 1.
2 = ,, Dec. 1.	15 = 1894 Jan. 1.
3 = 1893 Jan. 1.	. . . . .
. . . . .	. . . . .
. . . . .	19 = 1894 Mar. 30.

a character of movement can very easily produce slow progressive motions, and also from this reason the whole phenomenon wants to be watched incessantly and very carefully.

The astronomers and geodetists who are now associated in the International Geodetic Union, have invited the geologists to associate with them in this common research. Such an international organisation will be also useful and almost indispensable for a great part of the work of astronomical observatories.

It is to be hoped that Great Britain will now participate in this international union, embracing all other civilised nations. Such organisations, with their clear and reasonably limited aims, involve not only real economies and refinements of mental work, combined with diminutions of material expenses, but it is hoped that they will also have a great importance as slowly growing foundations of human and terrestrial solidarity.

SCIENCE IN THE MAGAZINES.

MR. HIRAM S. MAXIM gives, in the *National*, a brief description of his experiments on flying by means of aeroplanes. His flying machine, when finished and loaded with its water, its fuel, and three men, weighed very nearly 8000 lb., and the actual horse-power developed on the screws was 363 horse-power, with a screw-thrust of rather more than 2000 lb. The total width of the machine was over 200 feet. It was found that upon running the machine at thirty miles an hour very little load remained on the lower track, and at thirty-six miles an hour the whole machine was completely lifted.

The *Fortnightly* is remarkable this month for two critical articles by Prof. Karl Pearson and Mrs. Lynn Linton, respectively. Prof. Pearson assails Lord Salisbury's address to the British Association, and moans over the fact that Lord Kelvin courteously said that throughout it "there was the spirit of the student, the spirit of the man of science." Here is his opinion on it: "We find nothing in it which shows the spirit either of student or of man of science; it teems with fallacious conclusions, and whatever may have been intended by the author, it can only serve as an appeal to that gallery which is occupied by the reconstructed theological party." Mrs. Lynn Linton outpours the vials of her wrath upon Prof. Henry Drummond and his "Ascent of Man." "He brings his subject," says she, "which only the educated can rightly understand, down to the level of the ignorant. He strips science of her divinity, and sends her out as a cottage-maid, or rather as a young priest, of whom no one need be afraid. But he lets slip truth in this endeavour to extract milk for babes out of the meat for men; and his rendering of synthethic philosophy is both inadequate and shallow. Whatever is true is borrowed; whatever is false, strained, and inconclusive, is his own. His sin is the sin of plagiarism, with the additional offence of distortion in the lifting." Surely a writer never received a more terrible flagellation than this.

Brief descriptions will suffice for other articles of more or less scientific interest in the magazines received by us. Sir Robert Ball contributes to *Good Words* a paper on Galileo. The *Century* contains a continuation of Messrs. Allen and Sachtleben's account of their journey across Asia on bicycles; and a fine picture of an aurora, observed and sketched at Godthair on September 3, 1892, by Mr. F. W. Stokes, one of the members of the Peary Relief Expedition. Dr. Carl Lumholtz describes in *Scribner* the life and costumes of the Tarahumaris, the inhabitants of the Sierra Madre. In *Chambers's Journal* we find a diversity of instructive articles. Among the subjects scientifically treated are "British Ring-Snakes," "Dynamite," "Sweet Lavender," and "Sources of Power in Nature." Lovers of nature will find pleasure in an article entitled "In a Rock Pool," contributed by the Rev. Theodore Wood to the *Sunday Magazine*, and geographers will be interested in a description of the inhabitants of the Andaman Islands. Under the title "Spirit and Matter," Emma Marie Caillard philosophises, in the *Contemporary*, on such psychical subjects as were touched upon by Prof. Oliver Lodge in his British Association address in 1891.

SCIENTIFIC SERIALS.

Bulletin de l'Académie Royale de Belgique, No. 7.—Comparative study of the isothermals observed by M. Amagat and the isothermals calculated from M. Van der Waals's formula, by MM. P. de Heen and F. V. Dwelshauvers-Dery. A comparison of the theoretical and experimental isothermals shows that the molecules which constitute carbonic anhydride expand regularly as the temperature increases. The coefficient of mean molecular expansion, for temperatures between 30° and 258°, is sensibly equal to 0·001, a number which closely approaches the coefficient of expansion of liquids in general. To this intra-molecular dilatation corresponds the internal latent heat of dissociation, made evident by the variability of the specific heat of carbonic anhydride in the gaseous state. Since Van der Waals's equation furnishes fairly accurate values for the part o the isothermals situated to the right of the minimum, one might feel tempted to introduce another constant and to force the curve to pass through a supplementary point conveniently chosen to the left of that minimum. This would give much more satisfactory results, but they would have no value with