WE have on our table several volumes published by learned societies, but limits of space will not permit us to do more than refer to them briefly. One of these volumes is the twenty-second (new series) of the *Proceedings* of the American Association of Arts and Sciences, and contains twenty-two papers read before the Association between April 1894 and May 1895; among them being papers on the North American Centhophili, by Mr. S. H. Scudder; nitro-paraffine salts, and bivalent carbon, by J. U. Nef; wave-lengths of electricity on iron wires, by Mr. C. E. St. John; the blastodermic vesicle of *Sus scrofa domestica*, by Mr. A. W. Weyse; ternary mixtures, by Mr. W. D. Bancroft; a revision of the atomic weight of strontium, by Mr. T. W. Richards; and on the relation of hysteresis to temperature, by Messrs. F. A. Laws and H. E. Warren. Another volume to which we can only briefly refer is the *Atti d. Accademia d. Scienze Fisiche e Matematiche* of Naples (vol. ii second series). In this we find memoirs on Italian Hymenoptera, by Prof. A. Costa; on certain Abelian equations, by Prof. V. Thollame; comparison of Right Ascensions simultaneously determined at Capodimonte and Cordoba, by Prof. A. Nobile; earth-currents, by Prof. Palmieri; Italian fossil ichthyology, by Prof. F. Bassani; and several others. We have also received a volume of the *Journal of Conchology*, the first published under the direction of the Conchological Society; vol. xxvi. of the *Proceedings* of the Boston Society of Natural History (part iv. 1894-95); and a number of maps from the Geological Survey of Canada. One batch of these maps exhibits the principal auriferous creeks in the Cariboo mining district, British Columbia; a second bundle refers to the geology of Guysborough, Antigonish, and Pictou Counties, Nova Scotia; while a third contains a geological and topographical map of the southern part of the lake of the Woods and Rainy River, Ontario, Eastern Townships Map, Quebec, and a sheet showing the geological character of South-west Nova Scotia. Finally, we have to acknowledge the receipt of vol. v. part i. (second series) of the *Proceedings* of the California Academy of Sciences, a volume of nearly eight hundred pages filled with valuable papers on Californian natural history; and the second volume of "Beiträge zur Geophysik," edited by Prof. Dr. G. Gerland. In this volume we find a speculative paper on terrestrial magnetism, by Prof. A. Schmidt; a very long account and discussion of observations made with the horizontal pendulum at Strassburg, during 1892-94, by the late Dr. E. von Rebeur-Paschwitz; an extensive collection of observations of submarine earthquakes and eruptions, by Dr. E. Rudolph; and a critical study of the mean level of the solid crust of the earth, of the land and water areas, and of the relation between the land above sea-level and oceanic depressions, by Dr. H. Wagner.

OUR ASTRONOMICAL COLUMN.

ORBITS AND ORIGIN OF COMETS.—The investigations of Schiaparelli led to the conclusion that comets moving in parabolic orbits must have originally had a very small velocity with respect to the sun, and that, apart from planetary perturbations, the probability of elliptic orbits is very small. The latter fact is demonstrated in a somewhat different way by M. V. Wellmann (*Bulletin Astronomique*, vol. xii. p. 515), the absolute velocities of the sun and comets being introduced. This method leads to the conclusion that the formation of hyperbolas is much more probable than that of ellipses, and that ellipses of large dimensions are much less probable than smaller ones; further, the supposed parabolic orbits which have been calculated are probably nearly all hyperbolas.

In conformity with the nebular hypothesis, M. Wellmann regards the substance of which comets are formed as the débris of nebulous matter not attached to any system in the process of condensation, but in unstable equilibrium, and having nearly the same proper movement as neighbouring centres of condensation. Eventually assuming a hyperbolic orbit round a

neighbouring sun, the "cosmic cloud" passes off into space, and may become attached to our system *en route*.

M. Wellmann goes on to demonstrate that under the influence of a solar electrical repulsion, elliptic orbits will approach the parabolic form. Hence, in calculating the definitive orbits of comets, this repulsion should not be lost sight of; even neglecting planetary perturbations, a comet may not move rigorously in a conic section. In cases where calculation and observations are discordant, it is suggested that a reconciliation be attempted by supposing that the "constant of attraction" is itself variable, in consequence of the varying electrical repulsion. M. Wellmann also seems to be of opinion that this force of repulsion may be found sufficient to explain the inequalities in the movement of Mercury, which Leverrier ascribed to a possible intra-mercurial planet; the suggestion that the law of gravitation is not strictly true (*NATURE*, vol. li. p. 183), adds to the probability of this explanation.

COMET BROOKS, 1895.—Attention is drawn by Dr. Deichmüller to a striking similarity between the elements of Comet Brooks 1895 and those of the comet of 1652 (*Ast. Nach.*, 3322); this is shown by the following comparison, in which Kreutz's elements for Comet Brooks are adopted:—

Comet 1652.		Comet Brooks.	
T = 1652 Nov. 13		T = 1895 Oct. 21	
$\omega = 300^{\circ} 10' 6''$	} 1895	$\omega = 298^{\circ} 13' 0''$	} 1895
$\Omega = 91^{\circ} 33' 0''$		$\Omega = 83^{\circ} 9' 2''$	
$i = 79^{\circ} 27' 7''$		$i = 75^{\circ} 22' 8''$	
$q = 0.847$		$q = 0.839$	

The continued ephemeris for the comet, following Dr. Berberich, is as follows:—

Dec.		R.A.			Decl.
		h.	m. s.		
27	...	3	18 39	...	+68 45.1
28	...	3	9 42	...	68 34.2
29	...	3	1 38	...	68 22.1
30	...	2	54 22	...	68 9.2
31	..	2	47 51	...	+67 55.6

THE MOVEMENTS OF HORIZONTAL PENDULUMS.

THE movements of horizontal pendulums referred to in this note are those which have been observed in Japan and the Isle of Wight. In reports to the British Association on the earthquake and volcanic phenomena of Japan in the years 1883, 1884, 1885, 1887, 1888, 1892, 1893, and 1894, abstracts are given of work which has been carried out in that country in the investigation of earth tremors or pulsations, diurnal waves, and other earth movements. The Report for 1892 describes a pair of extremely light horizontal pendulums, the movements of which, with the aid of mirrors and lenses, were recorded on photographic plates and films, and gives some account of the analysis of the resulting records. The observations were continued during the following year, when it was observed that the direction of earthquake movement in many cases coincided with the direction in which strata had been folded to form mountain ranges bordering the Tokio plain. Another observation was that certain earthquakes had been preceded by an abnormal amount of tilting. During the last year, largely in consequence of the liberality of the Royal Society of London, I have been able to extend these observations, and records have been obtained from horizontal pendulums, each provided with photographic recording apparatus, from nineteen installations. The more important of these installations were as follows. At Tokio in my house, on a massive stone column. At a place 1000 feet distant, in an underground chamber, excavated in the alluvium on a concrete bed. At Kanagawa the observatory was in an artificial cave, driven at a depth of about 50 feet in soft tuff rock beneath its junction with overlying alluvium. At Yokohama two instruments were placed in a cave on the tuff rock, about two feet below its junction with the alluvium. At Kamakura two instruments were placed in a cave on hard tuff, which dips at an angle of 30° north-east.

These instruments were oriented so that their booms pointed north-west or north-east, or parallel and at right angles to the dip of the rocks. The localities mentioned are at distances from Tokio of twenty, twenty-three, and about thirty-three miles.

The remaining installations were on brick columns rising from a bed of concrete on the alluvium, the localities being chosen with regard to the surface configuration and the proximity or absence of a covering of forest or buildings which would influence the effects of solar radiation. Underground and in the caves, which represent seven out of the nineteen installations, the daily change in temperature was not appreciable on the diagram from a self-recording thermometer. At other stations this change was often very great.

The Instruments.

The pendulums consisted of a horizontal boom about 5 feet in length, held up by a fine brass wire. They had different degrees of sensitiveness. Usually the adjustment was such that the outer end of the boom was displaced 1 mm. by tilting the bed plate of the apparatus from $0^{\circ}1$ to $0^{\circ}5$. At the extremity of the boom there is a light metal plate with a slit in it parallel to the length of the boom. Underneath this floating slit, but at right angles to it, there is a narrow slit in the top of a box. Light, after passing through the two slits, goes into the box as a point which is received on a drum carrying a photographic film, which usually lasted one week.

No accuracy of adjustment is required, and if the pendulum is steady without the aid of a single lens, the photographic trace is a remarkably clear line.

If there are two slits—one broad and the other narrow—in the floating plate, two lines may be produced, one of which is thick, and the other extremely fine. For quick movements of the pendulum, the best diagram is given by the former, whilst for slow displacements the latter has the clearer definition.

A modification of these arrangements is one which I used in Japan, and which is now in operation at Shide, in the Isle of Wight. In this instrument the boom is built up of straw and reed about 2.5 feet long, and weighs less than .25 oz. At its outer end there is a small mica plate, which is blackened, and has two slits in it parallel to the length of the boom. At a distance of 1.5 inches from its inner end, where there is a brass socket and an agate cup, a pivoted weight is so arranged that it balances the outer part of the boom. The apparatus is therefore equivalent to an extremely light conical pendulum seismograph, which multiplies tremor-like motion about sixteen times, but which is at the same time very sensitive to changes in the vertical. When the pendulum has a period of sixteen or eighteen seconds, one millimetre deflection of the end of the boom indicates a tilting of $0^{\circ}70$. The record is received upon a roll of bromide paper passing beneath a fixed slit in the lid of a box, above which is the boom and mica plate. This moves at a rate of about forty-two millimetres per hour. Should this paper move at a varying speed, this is checked by an ordinary watch so placed upon the lid of the box with the fixed slit, that its long hand every hour crosses freely over a portion of this slit not covered by the floating plate, and by eclipsing the light, causes hourly time-marks to be made on the band of bromide. On many occasions I have caused the pendulum to move at *known* times, and subsequently determined the times at which these disturbances took place by measurements made on the bromide film after development. The errors usually varied between three and ten seconds.

These pendulums have worked well in damp caves and with unskilled assistants. One assistant was a shopkeeper's daughter, twelve years old, whose duty it was to refill and light a benzine lamp every twenty-four hours. The records obtained were very much freer from tremor effects than anything I have obtained when working with a pendulum, the boom of which was a two-inch piece of aluminium wire held in position by a quartz fibre, and giving its record by mirrors and lenses.

The movements recorded have been as follows.

(1) *The Wandering and Long-period Movements of Pendulums.*

All the horizontal pendulums wherever situated have slowly wandered from their normal position. Those on the rock have often gradually moved to one side and then returned, the double excursion usually taking from two days to a week. Underground on alluvium *within twelve feet of water-level* the wandering was at times so great that the spot of light left the film, which was two inches broad, and readjustments were often necessary. From the readings of the end of the pointers, it would appear that in some cases at least, had the pendulums been given sufficient time they might have returned to their starting point. The pendulum in my house, one thousand feet distant from those underground, but *thirty-six feet above water-level*, although usually more sensitive than those beneath the surface,

wandered to a less degree. These wanderings might be due to a local warping of the supporting column, but inasmuch as it has generally happened that the periods of great movement and of comparative rest of different instruments have coincided in time, it would seem that the movements are in all probability due to a more general cause. Because great movements have usually been marked (but by no means always) at or after a rainfall, some of them may be attributed to fluctuations in the volume and flow of underground water, the pendulum nearest to this water moving the most.

The other movements, especially those of the pendulum, situated in my house, and those of the instruments on the rock, have been accompanied by local earthquakes, conveying the impression that they represent actual rock bending, the earthquakes being interruptions in the process. As the number of observations are limited, and as I am not in a position to determine which of the earthquakes recorded in Tokio are of local origin, and which originated at a distance, although the materials for making this determination have been accumulated at the Central Observatory in Tokio, the matter is one requiring further attention.

Two pendulums on the alluvium, four hundred yards distant from each other and very differently installed, for periods varying between four and forty days, have moved at the same time in the same directions.

These movements may therefore be due to some general cause. A rough agreement with a barometric curve suggests the idea that the cause is due to variations in atmospheric pressure, but it is equally possible that they may be due to a greater evaporation or precipitation of moisture on one side of these stations than upon the other sides.

(2) *Diurnal Waves.*

By a diurnal wave I mean a deviation of the vertical during one portion of a given period of twenty-four hours in one direction, followed by a retrograde motion during the remaining portion of this interval. On rock foundations my instruments, which never had a sensibility exceeding 1 mm. deflection for a tilt of $0^{\circ}1$, have failed to show such a movement. With instruments having a greater sensibility it is likely that its presence would be detected. These movements, which may, for example, be shown by a westerly displacement of a pendulum through a distance of from 2 to 40 mm. from about 6 a.m. until about 3 p.m., and an easterly motion until the following morning, may be best studied from diagrams on films which have moved at a rate of about 3 or 4 inches per day.

In the underground chamber in the alluvium, within 12 feet of the surface, where the daily change in temperature was less than 1° C., the daily waves were often marked. On the surface at my house, on a good foundation protected by a long building, the wave was marked, but slight.

At stations protected on all sides by high trees from the sun it was feeble. At all other stations, where on one side at least there was open ground exposed to the sun, with the *exception of rainy or cloudy days, when the photographic trace was a straight line, it was very marked, the deflection sometimes amounting to 40 millimetres*. On one hill, from about 6 a.m. to 6 p.m. the motion was westwards, while at the other side of a swampy valley running N.N.W. the movements were at the same hour almost in a contrary direction. It would appear that on every fine day the trees on the hills on the two sides of this valley bow first towards and then away from each other.

For the present I am inclined to regard these phenomena as being due to a tilting of the surface in consequence of the evaporation of moisture. This effect extends to some depth.

On open ground in the morning more moisture is taken away from the eastern side of a station than from the western side, and therefore the eastern side, being relieved of a load, rises, and the pendulum swings westwards.

In the afternoon this action is reversed, and the pendulum turns eastwards.

The waves due to this effect differ in time of occurrence and in amplitude according to the character of the locality in which they are observed.

The movement at night is slight. It may be a continuation of the sun effect modified by the precipitation of dew from the atmosphere, and by the condensation of aqueous vapour rising in ground heated during the day but chilled on its surface after sunset. The sub-surface condensation sometimes represents a load one-tenth of that taken away by evaporation. Like dew

and evaporation, its amount varies daily, and with locality, and on two sides of a given station it reaches a maximum at different times.

Experiments bearing upon these Suggestions.

(1) Ten men and boys, representing a load of about 1000 lbs., at a distance of 15 feet from the stone column carrying the pendulum in my house, causes it to move as if the ground had been depressed upon the side of the load.

(2) By quickly emptying a well, which is distant about 100 feet from the above column, of about two tons of water, which was run off down a hill, the pendulum moved away from the well, behaving as if the ground had been relieved of a load on that side.

(3) A self-recording tide-gauge was set up in an unused well 80 yards distant from the underground chamber. This showed that the water in the well rose and fell $\frac{1}{4}$ to $\frac{1}{2}$ inch *twice* every 24 hours. The times of sinking, which occur in the morning and the evening, may correspond with the times at which the most water is being drawn from wells in the city. I have not determined whether these movements have any influence upon a small wave which is often superimposed upon the large diurnal wave.

(4) I find from experiment that on fine days the ground in my garden may lose by evaporation 4 or 5 lbs. of moisture per square yard, or from an area measuring 20 by 20 yards about 1 ton.

I also observe that during a bright fine day that, in most cases, pendulums move away from areas that are being relieved of loads in this manner, and which may therefore be rising.

(5) Because it often happens that a board which has been lying on the grass all night is found in the morning to be wet on its under side, whilst all around the grass may be dry, the following experiment was made on sub-surface condensation. Two shallow trays about 1 foot 6 inches square were filled with earth, and placed on a flat surface of earth in my garden. One of these trays had a bottom of sheet tin, whilst the other had a bottom of fine wire netting. These were weighed morning and evening, and it was found that sometimes the box with the fine wire netting had increased in weight, while the other had not changed. The inference from this is, that during a hot day the ground is sensibly heated to a depth of one foot. This was proved by diagrams from self-recording thermometers, which for periods of a week had been buried at varying depths. After sunset the surface of the ground is quickly chilled, and aqueous vapour rising into this is condensed to augment the surface weight.

An open area, which during a day may have lost more weight by evaporation than a neighbouring area which is covered, will, if both areas are connected with the same subterranean water supply, gain the most in weight, not only by an action of this sort, but also by the condensation of moisture as it escapes from the surface, and by the precipitation of moisture from the atmosphere. These actions may in part account for the retrograde motion of pendulums during the night. Although differential evaporations and condensations are apparently sufficient to account for certain observations made in Japan, other observations exist to which they are not so apparently applicable. The cause of diurnal waves is therefore not yet known with certainty.

(3) *Earth Tremors.*

The continuous photographic records taken in Japan have thrown much new light upon the occurrence of tremors, while an experiment made at Shide in the Isle of Wight, where a light horizontal pendulum has been established to record earthquakes having their origins in distant localities, has indicated a cause of movements which probably have often been attributed to movements of the ground.

We know that tremors are more frequent during the winter than during the summer, that they are frequent with a low barometer, and still more frequent when the locality of observation is crossed by a steep barometrical gradient. From these latter accompanying conditions, it may be inferred that tremors may occur whenever a strong wind is blowing, although near to the observing station the atmosphere may be perfectly calm. Recent observations in Japan have shown that tremors are more frequent during the night than they are during the day, and that maxima of motion are reached between 5 and 9 a.m. In fact, some instruments have always shown movements about these hours. One very important observation is that the greatest movements have been recorded by the lightest pendulums. For

example, a pendulum having a boom from one quarter to four inches in length is a better tremor recorder than one which has a boom several feet in length.

The pendulum at Shide was set up upon a newly-built brick pier. Because moisture was given off from this, the inside of the covering case became exceedingly damp, and the bromide film became sticky. To overcome this difficulty, two trays of calcium chloride were placed inside the covering. A few minutes after this it was observed that the pendulum commenced to swing. When the calcium chloride was removed the pendulum came to rest. This experiment was repeated several times, and the conclusion arrived at was that rapid desiccation produced air currents of sufficient intensity to cause a light pendulum to move, and the diagrams of these movements are not distinguishable from those attributed to *earth* tremors. Although experiment has shown that differences in temperature of the walls enclosing a light pendulum will cause the same to swing, I have no reason to think that movements due to such causes have been recorded. All that can be said at present is that a difference in the rate at which moisture is absorbed by or evaporated from the different walls of a casing covering a light pendulum, may cause the same to swing. Before we should attempt to explain why such movements are marked at particular hours, and occur with certain meteorological conditions, the necessity of further experiments is obvious. Air currents can hardly explain a set of tremors lasting several hours, where a seventeen seconds pendulum moves back and forth with uniform amplitude and a uniform period of two or three minutes.

(4) *Earthquakes.*

At Kamakura, on the hard rock, the greatest earthquake motion has been given by the pendulum which records tilting parallel to the dip—suggesting the idea that in this direction there is an easier yielding (like the opening and shutting of a concertina) than there is in a direction parallel to the strike. The movements, even for unfelt earthquakes, are sometimes as much as 40 mm., and a disturbance may continue for several hours. On March 22, I and my colleague, Mr. C. D. West, watched an earthquake for 1 hour and 47 minutes, during which time the pendulum did not *swing*, but was *forced* backwards and forwards intermittently, and with extreme irregularity. These earthquakes are in the form of earth waves, and usually come from a great distance. A sharp shock which may be felt throughout Tokio and at many places in the country, does not disturb the pendulums, and it is difficult to find a blurr on the photographic trace.

As in previous years, before certain local earthquakes I have observed abnormal tilting, an explanation for which is suggested in the section on the wandering of pendulums. It is seldom that abnormal tilting has taken place without local disturbances. Local disturbances, unless they are large, which fortunately is of rare occurrence, are only recorded by seismographs.

One disturbance which I recorded at three stations in Japan was one which had its origin near to the antipodes of that country in the Argentine Republic. The conclusion to be derived from this and other observations is that a large earthquake may be recorded at any point upon the surface of the earth. The preliminary tremors seem to reach distant places with a velocity twice or three times that with which mechanical vibrations can be transmitted through glass or steel. Possibly they come *through* our earth, which therefore may have a higher effective rigidity than hitherto supposed. The undulatory motions which follow the tremors may be transmitted as surface quasi-elastic gravitational waves. Their velocity of propagation lies within the limits of expectation. The chief object of the instrument established in the Isle of Wight is to determine whether it is sufficient to record the unfelt movements due to earthquakes originating in distant localities.

The first certain records of earthquakes having their origin at great distances were obtained by Dr. E. von Rebeur-Paschwitz, whose recent death has deprived the world of one of the most active workers in the new field which has been opened to seismologists.

JOHN MILNE.

THE ANTWERP METEOROLOGICAL CONGRESS.

TAKING advantage of the attendance of numerous visitors, scientific and otherwise, that the Antwerp Exhibition was likely to attract, it was proposed to hold, under the auspices of the Geographical Society of that city, a congress on meteor-