support of the column of lava within the chimney. This lowering of level probably produced the extension outwards of the eastern dyke, and the lateral outlet of lava was consequently lowered. This was confirmed by the much increased outflow of lava coincident with the falling in of the cone.

During the first week in July the volcano appeared from Naples to be very quiet; indeed, less vapour was escaping from the summit than at any time during the last seven years. From time to time the vapour was, from the gradually increasing pressure, able to burst its way through the loose materials that choked the outlet, when a puff of smoke would be visible of a dark purplish-black colour, due to its being charged with volcanic ash derived from the churning up and trituration of the lava fragments, scoria, and lapilli it had to traverse in its escape. At the same time a slight reflection was to be seen at night, indicating that the lava surface, although lowered, was not so to any great extent.

On this day, July 8, the lava which had always been gradually advancing, had crossed the southern end of the Val d'Inferno, and flowing down one of the wooded ravines on the property of the Prince of Ottajano, where it destroyed a number of trees, it continued its course, overwhelming some vine-gardens. On July 12 the number and quantity of the black smoke puffs was very great, and the crater was in the full ash-forming stage, and towards night the vent had been considerably cleared, so that the reflection was well marked. The next day the smoke issued freely and uncharged with ash. The change that took place on the 12th was no doubt due to the lava rising in the chimney consequent upon the lateral outlet getting choked; as on the 11th, the abundant flow of lava became very much diminished.

On July 20 the puffs of dark smoke again appeared, indicating a return of the crumbling in of the crater; this was again due to the lowering of the lava level, and, as was expected, the fluid rock issued in great abundance the following day, again destroying trees and vine-gardens. The next day the lava was still flowing in abundance, so as to form a bright streak on the slope of the great cone. The outflow continued to gradually diminish until the 30th, the crater above remaining inactive. On the latter date, however, the lava rose again sufficient within the chimney to cause the vapour to find a passage through the materials choking the main vent, so that on that day the puffs of black smoke were again abundant, and accompanied by the ejection of partially triturated subangular old lava and scoria fragments. In the evening bright bursts were well marked, showing that the vent was again cleared. The two following days the volcano maintained the third degree of activity (*Rep. Brit. Assoc.*, 1885, p. 395).

During the first week of August the lava again flowed rather freely from the mountain's side, whilst from its summit hardly any vapour escaped except from time to time a puff of blaek smoke. On August 7 a visit was paid to the crater. The cone of eruption has been reduced in height about 30 metres, and its remnants form a low crater ring inclosing a crater of oblong form having a diameter of about 80 × 60 metres. Its greater axis lies in a line from about E.S.E. to W.N.W., and its bottom is double, so that it seems to result from two craters closely overlapping each other. The crumbling-in process was still going on, and the trituration of the loose stones and the charging of the vapour puff by the ash or sand could be watched from a distance of a few yards. I was successful in obtaining two ordinary and two instantaneous photos of the interior of the crater, only the eastern half of which, however, was active.

The principal facts that may be gathered from the study of the phenomena of Vesuvius during these few months are rather confirmations of what the author has described as the mechanism of lateral eruptions, which may be summed up thus. The lowering of lava level within the chimney due to a lateral outlet removes the support the former gave to the walls of the crater and vent, which in consequence tumble in and choke more or less of the main outlet. Next the vapour contained in the lava may be compelled to escape laterally, but has a natural tendency not to do so, but rather to seek its path straight upwards. If the lateral outlet becomes choked, the lava immediately commences to rise in the chimney, and the escaping vapours burst through the loose materials in the chimney in puffs, grinding and triturating them, carrying upwards their dust, which tints the smoke of a dark colour, and, falling around the volcano, constitutes one of the forms of "volcanic ash," the chemical composition of which represents that of all the rocks triturated *plus* the saline substances condensed from the smoke. If one walks across this ash when damp, one may notice the immediate plating of their boot-nails with copper, showing the abundance of the chloride of that metal. H. J. JOHNSTON-LAVIS

THE ADELAIDE BOTANIC GARDEN AND GOVERNMENT PLANTATION

THE report of Dr. Schomburgk on the progress and condition of the Botanic Garden and Government Plantation, Adelaide, during the year 1885 has just reached us. Speaking first of the rainfall, Dr. Schomburgk says that the year was one of the driest and most ungenial that he ever had to contend with, the rainfall being no more than 15·887 inches, which was 2·851 inches less than the fall of 1884, and 5·272 below the average rainfall during the previous forty years. During September, October, November, December, and January no more than 3 inches of rain fell, and the heat during these months was abnormally great. The drought and heat combined had an injurious effect upon the vegetation, especially upon many of the trees and shrubs in the Botanic Garden, natives of cooler countries; the losses sustained, however, were not so great as was expected, owing to an abundant supply of water. On the other hand, in May and June severe frosts were experienced, so that tropical and sub-tropical plants and shrubs suffered greatly.

On the question of the introduction and acclimatisation of new economic plants, Dr. Schomburgk records his experience with many that have been widely distributed through the agency of the Royal Gardens, Kew, and have become known and established in other colonies as well as in India, such, for instance, as the Kumara (*Ipomœa chrysorrhiza*), the tubers of which form an article of food in New Zealand. Dr. Schomburgk says he believes that the plant will grow well in the gullies, because the climate there is cooler and moister than on the plains, and to some extent approaches that of New Zealand. The Gingelly oil plant (*Sesamum indicum*) is also reported upon favourably. The seeds were sown in drills in the open ground in October, and came up in about fourteen days. Considering that neither the dry spring nor the summer heat affected the plants, there seems no doubt that the species can be successfully cultivated in South Australia. The plant is an annual, and is very largely grown in warm countries for the sake of the sweet limpid oil now so much used for mixing with olive oil.

Under the head of *Rhopala* sp. an announcement is made of the receipt from Kew of a parcel of seeds of a tree belonging to the above-named genus, a native of Columbia, with the following extract from a letter of Mr. W. T. Thiselton Dyer:—"The Rhopala is a small contorted tree growing to about twenty feet in height. It is remarkable for being absolutely indestructible by fire, in large districts where the dry pastures and bush are burnt twice a year. Its resistance to fire enables it to exist to the exclusion of all other trees and bushes as a perfect natural plantation. The periodical burning destroys everything except this tree. The resemblance to a plantation is moreover enhanced by the circumstance that the trees never form thickets, and they are thickly and almost systematically dispersed over the land. The tree delights in the most sterile soils, but always of a stony or shingly character. Sometimes it grows in places so barren that even grass cannot exist. This suggests the idea that it may be turned to account in sterile districts within the tropics." Dr. Schomburgk expresses some doubt whether the plant will thrive out of doors with them, but thinks it may do well in the Northern Territory.

The Herbarium and Museum have both been considerably enriched by additional specimens during the year, so that the utility and efficiency of the whole establishment are thoroughly maintained.

THE AMERICAN ASSOCIATION

FROM the report in *Science* of the Buffalo meeting of the American Association we condense the following brief summary:—

Prof. Gibbs's masterly address, in the Section of Mathematics and Astronomy, upon the subject of "Multiple Algebra," was too long and of too technical a nature for presentation in full to our readers. His opening remarks were as follows:—

"It has been said that 'the human mind has never invented a labour-saving machine equal to algebra.' If this be true, it is but natural and proper that an age like our own, characterised

by the multiplication of labour-saving machinery, should be distinguished by an unexampled development of this most refined and most beautiful of machines. That such has been the case, no one will question. The improvement has been in every part. Even to enumerate the principal lines of advance would be a task for any one—for me, an impossibility. But if we should ask in what direction the advance has been made, what is to characterise the development of algebra in our day, we may, I think, point to that broadening of its fields and methods which gives us 'multiple algebra.'"

The speaker then gave a critical historical review of the different contributions of Hamilton, Möbius, Grassmann, Saint-Venant, Cauchy, Cayley, Hankel, the Peirces, father and son, and Sylvester, to these new methods of mathematical analysis, showing the additions and developments made by each to the various subjects.

In the second part of the paper Prof. Gibbs criticised the methods of some modern writers on these subjects, showing how they failed to grasp the full significance and bearings of the matters they were dealing with, being too much hampered by the old ideas and methods of simple algebra.

In the third part of his paper Prof. Gibbs directed attention more critically to multiple algebra itself, and inquired into its essential character and its most important principles.

Then followed a long discussion of the fundamental conceptions and methods of modern mathematics, which nothing but publication in full could render intelligible, and that only to mathematicians.

The fourth part of the paper was devoted to consideration of some of the applications of multiple algebra. From this we quote the following:—"First of all, geometry, and the geometrical sciences which treat of things having position in space, —kinematics, mechanics, astronomy, crystallography,—seem to demand a method of this kind, for position in space is essentially a multiple quantity, and can only be represented by simple quantities in an arbitrary and cumbersome manner. For this reason, and because our spatial intuitions are more developed than those of any other class of mathematical relations, these subjects are especially adapted to introduce the student to the methods of multiple algebra. Here Nature herself takes us by the hand, and leads us along by easy steps, as a mother teaches her child to walk. In the contemplation of these subjects Möbius, Hamilton, and Grassmann formed their algebras, although the philosophical mind of the last was not satisfied until he had produced a system unfettered by any spatial relations. It is probably in connection with these subjects that the notions of multiple algebra are most widely disseminated. Maxwell's 'Treatise on Electricity and Magnetism' has done so much to familiarise students of physics with quaternion notations, that it seems impossible that this subject should ever again be entirely divorced from the methods of multiple algebra. I wish that I could say as much of astronomy. It is, I think, to be regretted that the oldest of the scientific applications of mathematics, the most dignified, the most conservative, should keep so far aloof from the youngest of mathematical methods; and standing, as I do to-day, by some chance, among astronomers, although not of the guild, I cannot but endeavour to improve the opportunity by expressing my conviction of the advantages which astronomers might gain by employing some of the methods of multiple algebra. A very few of the fundamental notions of a vector analysis, the addition of vectors and what quaternionists would call 'the scalar part and the vector part of the product of two vectors' (which may be defined without the definition of the quaternion)—these three notions, with some four fundamental properties relating to them, are sufficient to reduce enormously the labour of mastering such subjects as the elementary theory of orbits, the determination of an orbit from three observations, the differential equations which are used in determining the best orbit from an indefinite number of observations by the method of least squares, or those which give the perturbations when the elements are treated as variable. In all these subjects the analytical work is greatly simplified, and it is far easier to get the best form for numerical calculation than in the use of the ordinary analysis."

Then followed illustrations of the various methods of applying multiple algebra to different classes of problems.

Prof. Brackett's address on "The Seat of the Electromotive Force" was essentially a *résumé* of the history of the investigations to find the source of the current in galvanic batteries. No attempt was made to settle the question, which has been so long a bone of contention.

In his address to the Section of Biology, Dr. H. P. Bowditch, of Boston, concluded that investigations into the chemical changes, the heat production, and the fatigue of active nerves, all tend to results more favourable to a kinetic than to a discharging theory of nerve action.

In the Section of Anthropology a novel and ingenious method of getting an insight into the unconscious mechanism of authorship was described by Mr. T. C. Mendenhall, under the title "Characteristic Curves of Composition." The method consists in counting the number of words of each length, from one letter to fourteen, fifteen, or as long as were found, and plotting the result on a curve, in which the abscissæ represented the number of letters in the word, and the ordinates the number of words per thousand of each length. It was shown that while the curve resulting from each thousand words was not entirely regular, that resulting from five thousand was much more regular, and that from ten thousand almost entirely so. The inference from this was, that the phenomenon which the curve represented was a regular one, and that it was an expression of the peculiar vocabulary of the author. Moreover, by comparing the respective curves, one would be able to judge whether two works were written by the same author, and perhaps even decide the controversy whether Bacon wrote Shakespeare. Mr. Mendenhall's method was to count a thousand words at a sitting, and then turn to another part of the book. One soon acquired the art of counting at a glance the number of letters in each word, and, with an assistant to record the result, one thousand words could be counted in a half-hour. Curves derived from Dickens ("Oliver Twist") and Thackeray ("Vanity Fair") were remarkably similar, thus suggesting that the subject-matter might cause the peculiarity of the curve, while those from John Stuart Mill ("Political Economy" and "Essay on Liberty") differed from them in having more long words and fewer short ones, though words of two letters (prepositions mainly) were most abundant in Mill. The average length of the novelists' words was 4·38, and that of the philosopher 4·8.

The geological interest of the meeting at Buffalo naturally centred in the excursion to and discussion of the Falls and gorge of Niagara. Dr. Pohlman, of Buffalo, described the district to be visited on Saturday, and called particular attention to the occurrence of drift-filled antecedent channels on the line selected by the post-Glacial overflow of Lake Erie, which would gradually diminish the amount of rock-cutting required in the excavation of the present gorge, and thus reduce the time since the overflow began. The geological members of the excursion party therefore gave close attention to these matters, and, as a whole, regarded the heavy drift between the sloping rocky banks at the whirlpool, and the wide, open valley, with its plentiful drift at St. David's, as sufficient evidence of an old buried channel connecting these points, and probably heading up above the whirlpool towards the bridges. But there seemed no sufficient reason for any confident belief in a branching old valley from the whirlpool towards the Lewiston bluffs: in making this lower part of the gorge there must have been a long period of deep rock-cutting between the first leap of the Falls over the bluff and the time of their discovering the old drift-channel and the whirlpool. The estimate of the age of the Falls was presented by Messrs. Woodward and Gilbert, of the Geological Survey, and their remarks greatly interested a large audience that had gathered on the announcement of the discussion. Mr. Woodward had just completed a survey of the Horseshoe Falls, and by comparing his results with those of the State Survey in 1842, and of the Lake Survey in 1875, he found an average recession for the whole face of the Fall of about $2\frac{4}{10}$ feet per annum; but as the central parts of the curve, where the water is deepest, has retreated from 200 to 275 feet in the eleven years since 1875, an average retreat of 5 feet per annum does not seem at all improbable. Mr. Gilbert then discussed the beginning of the Falls as controlled by the drainage of the lakes. When the retreating ice-sheet stood so as to obstruct the St. Lawrence and Mohawk drainage channels to the east, a broad sheet of water, representing a confluent of Erie and Ontario, stood at a high level over the present Niagara limestone plateau, and probably drained south-westward to the Ohio. When further melting opened the Mohawk Channel, the great double lake fell to a lower level, and was separated into its two members, Ontario sinking to the level of its outlet at Rome in Central New York, but Erie being held higher by the rim of the Niagara plateau. This was the birth of the river and the Falls, and since then they have been at work on the gorge. The age of the falls thus carries us back to a tolerably definite point in

the decline of the Glacial period. On the supposition of a uniform rate of recession, the age of the Falls equals the length of the gorge divided by the annual recession; but the rate has been undoubtedly varied by changes in a variety of conditions, which must be allowed for. As thus qualified, Mr. Gilbert gave it as his conclusion that the maximum length of time since the birth of the Falls by the separation of the lakes is only 7000 years, and that even this small measure may need significant reduction.

In the Section of Chemistry, H. C. Bolton, of the Committee on Indexing Chemical Literature, after presenting their report showing the large amount of valuable work which was being done, read a paper on the confusion which exists in the abbreviations employed in chemical bibliography, and the desirability of uniformity in designations of scientific periodicals.

C. F. Mabery's paper "On the Products of the Cowles Electric Furnace," was of particular interest, and attracted much attention. He stated that the past year had been devoted more especially to the development of an increased commercial efficiency of the furnace, so that now 300 horse-power could by means of a large dynamo, be applied with greater economy in the results; and by coating the charcoal employed in the furnace with lime, by soaking it in lime-water, the production of graphite was largely avoided, and a marked improvement in the working of the furnace introduced. The results—although, as compared to what would eventually be accomplished by electric smelting, they may seem crude—have reached a stage where their commercial success can be demonstrated. It was also found that when the electrodes entered the mixture in a slanting position the product was increased. They are now also moved in and out with advantage, being gradually withdrawn as the resistance falls. Prof. Mabery replied to the criticisms of Hehner of Berlin, Siemens, and others, that no new principle was involved, showing that the Cowles furnace is quite different from all hitherto constructed, and the only one of practical application by which a dynamo of 300 horse-power could be used, as by means of a resistance-box and the arrangement of the furnace, the sudden breaking of the current is prevented from burning out the dynamo. The presence of copper for the reduction of aluminium was shown to be unnecessary; and, by complete exclusion of air from the furnace, buttons of the metal were easily obtained. A product which has attracted considerable attention during the past year is obtained by reducing aluminium in presence of iron. A cast iron is formed containing sometimes as much as 10 per cent. of aluminium, and this product is used to facilitate the working of crude iron, and to introduce into the various grades a small percentage of aluminium. In the reduction of aluminium in the presence of copper a yellow product is frequently taken from the furnace, which is composed of metallic aluminium to the extent of one-half or three-fourths, the balance being silicon and copper. It is also formed in the absence of copper, and then contains a higher percentage of aluminium, and always contains nitrogen. It has a resinous lustre, and decomposes water at 100°.

In the Section of Physics, Prof. T. C. Mendenhall prefaced his paper on "Electric Thermometry" by saying that the strictures upon the mercurial thermometer should not be carried too far. It has been of great value, though it may now fail to meet new demands. Electric thermometry is receiving especial investigation at the Signal Office, particularly from the meteorological stand-point, with some promising results. Prof. Mendenhall reported the progress which had been made in the study of atmospheric electricity during the past year. It is not time to begin to think of the origin of atmospheric electricity. The problem is its distribution and the relation, if there be any, to weather changes. Some very interesting results have been reached. In ordinary weather the electrical condition is undergoing constant and rather wide variations, which are very local, as two collectors only a few feet apart may give curves differing considerably, though similar in their wider variations. When an electrical storm occurs, the curves over a wide area may be similar in general outline. Prof. Mendenhall also noted a phenomenon entirely new to him; namely, that resistance-coils, after a current it passed through them for some time, upon short-circuiting will yield a reverse current for hours. This phenomenon can no doubt be classed under the general head of polarisation, yet by simple polarisation it would be difficult to account for persistence of current. This makes caution necessary in the use of resistance-coils, in order that any effects of this kind may be carefully noted. In one instance the apparent resistance of a coil was found to increase fourfold when the current was reversed.

A paper by Prof. Abbe created some discussion. The point of the paper was that, as the force of gravity varied from the equator to the poles, 30 inches of mercury in the barometer indicated a less gaseous pressure, and consequently less density of the atmosphere, at the equator than 30 inches at the poles, and hence a correction for latitude should be introduced in allowing for refraction. He showed that, for the difference of latitude of Pulkowa and Washington, it would make 0″·1 difference in the refraction at 45° of zenith-distance, and might be sufficient partly to account for differences in systems of star declinations which depended upon observations at great zenith-distances.

In the Section of Biology, the paper of Messrs. J. M. Coulter and J. N. Rose, giving a synopsis of the North American pines, based on leaf-structure, was of especial value from a systematic stand-point, from the fact that any species in this somewhat difficult group can at once be distinguished by the peculiarities of its minute leaf structure; and the results of the author's observations are shown to be worthy of attention from the fact that a classification based on these characters is, in its broader features, closely like that of the late Dr. Engelmann, which, as is well known, took into consideration the whole tree.

The relations of germs to disease naturally occupied a prominent place in the proceedings of the Section, and the presence of over half a dozen investigators in this line made the discussions interesting. Dr. D. E. Salmon read two papers bearing on the causes of immunity from a second attack of germ diseases. There are three possible explanations:—(1) Something is deposited in the body during the attack which is unfavourable to the germ; (2) something has been withdrawn which is necessary to its development; (3) the tissues have acquired such a tolerance for the germ or for an accompanying poison that they are no longer affected by it. Dr. Salmon favoured the last view, and gave details of a large number of experiments to substantiate his opinion. He said that Metchinkoff's phagocyte theory was not wholly satisfactory, and that large doses of the germs were more powerful than small ones. He attributed their action to a poison which was a result of their growth, and thought that a large dose had a greater effect because the poison benumbed or killed the cells, thus giving the Bacteria a better chance to grow and to thus produce more poison.

Dr. Joseph Jastrow gave an account of some physiological observations on ants, in which he was able, by simple but ingenious means, to study the rate of walk of these insects, and stated that his results, so far as they went, confirmed the opinions of others that the smaller the animal the more rapid the step, and also the more quickly fatigue was produced. Dr. Jastrow also had some observations on the dreams of the blind, taken mostly from persons who had lost the sense of sight before the age of five. In these cases the dreams were all in terms of hearing. In the case of Laura Bridgeman the dreams were apparently based on touch. In persons who become blind between five and seven, sight terms played an important part in dreams. The relation of these facts to the development of the sight-centres was pointed out.

PHOTOGRAPHIC DETERMINATIONS OF STELLAR POSITIONS[1]

IT has been suggested that a short account of my work upon stellar photographs for the attainment of accurate observations might be acceptable to the astronomical section. My intention had been to attend this meeting as a listener and learner only, but I comply with the suggestion the more readily, since, by a notable coincidence, I spoke upon the same subject in this place just twenty years ago this week. It is true that my communication then was only an oral one, and never reduced to writing, for the successful establishment of the Atlantic cable, of which I had received notice that day, called me away suddenly, before the time fixed for the regular presentation; but an elaborate written memoir upon the subject had been presented to the National Academy, ten days previous, at Northampton.

The early history of celestial photography is demonstrably and exclusively American; and its use as a method of delicate quantitative research is very markedly so. Without entering upon

[1] Paper read at the Buffalo Meeting of the American Association for the Advancement of Science, August 20, 1886.