The average speed is about 18 kilometres per hour with a train of fifty-five tons. Besides the locomotives, automobile carriages equipped up to 240-horse power are provided for the greater part of the passenger traffic, and these trains run at 36 kilometres per hour. Nothing could have been smoother or more satisfactory than the way in which the train (hauled in this case by one locomotive) was stopped and started, and it got up its speed with satisfactory quickness. It may be safely predicted that though this is the first railway of the type (as distinguished from a tramway) it will not be the last, for the transmission of current at 16,000 volts does not demand wires of more than two millimetres diameter for the distances mentioned. No difficulty seems to be experienced in insulation. Ordinary insulators of the double petticoat type without oil are employed, and no special precautions are taken with regard to the posts on which these wires are supported except to inscribe upon them a genial warning as to the fate likely to befall anybody meddling with them.

The railway up the Jungfrau is also a very interesting work, and an excellent day was spent in a visit to it. It goes up to the Rothstock a long way above the Wengern Alp, and there it ends at present in a tunnel. It happened that while some of the party were standing close to the locomotive in the tunnel the line was struck by lightning, the fuses blown in the power station, and the automatic break on the locomotive instantly went into action, though the train was at rest. From the electrical point of view, there was not much to be seen on the Jungfrau Railway, but we had splendid weather, and regarded the trip as a day's holiday.

On the whole we may, perhaps, say that we saw more, but not better, electrical work than can be done in England. We saw that Swiss engineers have the courage of their convictions, and have done more in railway work than most of us had ever dreamed of; and we saw that, as regards the carbide and similar industries, we cannot hope to compete in England till we can get at something cheaper than steam power. On the other hand, English industries in general cannot be regarded as threatened by Swiss enterprise; and Switzerland itself, regarded as a manufacturing country, requires (as Mr. Raworth remarked) to be rolled and to have its lakes filled up.

RICHARD THRELFALL.

THE BRITISH ASSOCIATION.

SECTION K.

BOTANY.

OPENING ADDRESS BY SIR GEORGE KING, K.C.I.E., LL.D., F.R.S., PRESIDENT OF THE SECTION.

A Sketch of the History of Indian Botany.

THE earliest references in literature to Indian plants are, of course, those which occur in the Sanskrit classics. These are, however, for the most part vague and obscure. The interest which these references have, great as it may be, is not scientific, and they may therefore be omitted from consideration on the present occasion. The Portuguese, who were the first Europeans to appear in India as conquerors and settlers, did practically nothing in the way of describing the plants of their Eastern possessions. And the first contribution to the knowledge of the botany of what is now British India was made by the Dutch in the shape of the "Hortus Malabaricus," which was undertaken at the instance of Van Rheede, Governor of the territory of Malabar, which during the latter half of the seventeenth century had become a possession of Holland. This book, which is in twelve folio volumes and is illustrated by 794 plates, was published at Amsterdam between the years 1686 and 1703, under the editorship of the distinguished botanist Commelyn. Van Rheede was himself only a botanical amateur, but he had a great love of plants and most enlightened ideas as to the value of a correct and scientific knowledge of them. The "Hortus Malabaricus" was based on specimens collected by Brahmins, on drawings of many of the species made by Mathæus, a Carmelite missionary at Cochin, and on descriptions originally drawn up in the vernacular language of Malabar, which were afterwards translated into Portuguese by Corneiro, a Portuguese official in Cochin, and from that language finally done into Latin by Van Douet. The whole of these operations were carried on under the general superintendence of Casearius, a missionary at Cochin. Of this most interesting work the plates are the best part; in fact, some of these are so good that there is no difficulty in identifying them with the species which they are intended to represent. The next important contribution to the botanical literature of Tropical Asia deals rather with the plants of Dutch than of British India. It was the work of George Everhard Rumph (a native of Hanover), a physician and merchant, who for some time was Dutch Consul at Amboina. The materials for this book were collected mainly by Rumphius himself, and the Latin descriptions and the drawings (of which there are over one thousand) were his own work. The book was printed in 1690, but it remained unpublished during the author's lifetime. Rumph died at Amboina in 1706, and his manuscript, after lying for thirty years in the hands of the Dutch East India Company, was rescued from oblivion by Prof. John Burman, of Amsterdam (commonly known as the elder Burman), and was published under the title of "Herbarium Amboinense," in seven folio volumes, between the years 1741 and 1755. The illustrations of this work cover over a thousand species, but they are printed on 696 plates. These illustrations are as much inferior to those of Van Rheede's book as the descriptions are superior to those of the latter. The works of Plukenet, published in London between 1696 and 1705, in quarto, contain figures of a number of Indian plants which, although small in size, are generally good portraits, and therefore deserve mention in an enumeration of botanical books connected with British India. An account of the plants of Ceylon, under the name "Thesaurus Zeylanicus," was published in 1737 by John Burman (the elder Burman), and in this work many of the plants which are common to that island and to Peninsular India are described. Burman's book was founded on the collections of Paul Hermann, who spent seven years (from 1670 to 1677) exploring the flora of Ceylon at the expense of the Dutch East India Company. The nomenclature of the five books already mentioned is all uninominal.

Hermann's Cingalese collection fell, however, sixty years after the publication of Burman's account of it, into the hands of Linnæus, and that great systematist published in 1747 an account of such of the species as were adequately represented by specimens, under the title "Flora Zeylanica." This Hermann herbarium, consisting of 600 species, may still be consulted at the British Museum, by the Trustees of which institution it was acquired, along with many of the other treasures possessed by Sir Joseph Banks. Linnæus's "Flora Zeylanica" was followed in 1768 by the "Flora Indica" of Nicholas Burman (the younger Burman)—an inferior production, in which about 1500 species are described. The herbarium on which this "Flora Indica" was founded now forms part of the great Herbarium Delessert at Geneva.

The active study of botany on the binominal system of nomenclature invented by Linnæus was initiated in India itself by Koenig, a pupil of that great reformer and systematist. It will be convenient to divide the subsequent history of botanic science in India into two periods, the first extending from Koenig's arrival in India in 1768, to that of Sir Joseph Hooker's arrival in 1849; and the second from the latter date to the present day.

The pioneer John Gerard Koenig was a native of the Baltic province of Courland. He was a correspondent of Linnæus, whose pupil he had formerly been. Koenig went out to the Danish settlement at Tranquebar (150 miles south of Madras) in 1768, and at once began the study of botany with all the fervour of an enthusiasm which he succeeded in imparting to various correspondents who were then settled near him in Southern India. These friends formed themselves into a society under the name of "The United Brothers," the chief object of their union being the promotion of botanical study. Three of these brothers, viz. Heyne, Klein and Rottler, were missionaries located near Tranquebar. Gradually the circle widened, and before the century closed the enthusiasm for botanic research had spread to the younger Presidency of Bengal, and the number of workers had increased to about twelve, among whom may be mentioned Fleming, Hunter, Anderson, Berry, John, Roxburgh, Buchanan (afterwards Buchanan-Hamilton), and Sir William Jones, so well known as an Oriental scholar. At first it was the custom of this brotherhood merely to exchange specimens, but gradually names began to be given, and specimens, both named and unnamed, began to be sent to botanists of established reputation in Europe. Many plants of Indian origin came thus to be described by Retz, Roth, Schrader, Willdenow, Vahl and

Smith. Rottler was the only member of the band who himself published in Europe descriptions of any of the new species of his own collecting, and these appeared in the "Nova Acta Acad. Nat. Curiosorum" of Berlin. A little later Sonnerat and other botanists of the French settlement at Pondicherry sent large collections of plants to Paris, and these were followed at a considerably later date by the collections of Leschenhault. These French collections were described chiefly by Lamarck and Poiret. Hitherto botanical work in India had been more or less desultory, and it was not until the establishment in 1787 of the Botanic Garden at Calcutta that a recognised centre of botanical activity was established in British India. Robert Kyd, the founder of that Garden, was more of a gardener than a botanist. He was, however, a man of much energy and shrewdness. The East India Company was still in 1787 a trading company, and a large part of their most profitable business was derived from the nutmegs and other spices exported from their settlements in Penang, Malacca, Amboina, Sumatra, and other islands of the Malayan Archipelago. The Company were also in those days the owners of a fine fleet of sailing vessels, and the teak of which these ships were built had to be obtained from sources outside the Company's possessions. The proposal to found a botanic garden near Calcutta was thus recommended to the Governor of the Company's settlements in Bengal on the ground that, by its means, the cultivation of teak and of the Malayan spices might be introduced into a province near one of the Company's chief Indian centres. Kyd, as a Lieutenant-Colonel of the Company's engineers, and as secretary to the Military Board at Calcutta, occupied a position of considerable influence, and his suggestion evidently fell on no unwilling ears; for the Government of Bengal, with the promptitude to accept and to act on good advice in scientific and semi-scientific matters which has characterised them from the day of Kyd until now, lost no time in taking steps to find a site for the proposed garden. Colonel Kyd's official proposal was dated June 1, 1786, and, in a despatch dated August 2, the Calcutta Government recommended Kyd's proposal to the Court of Directors in London. Posts were slow and infrequent in those days, and the Calcutta Government were impatient. They did not wait for a reply from Leadenhall Street, but in the following July they boldly secured the site recommended by Colonel Kyd. This site covered an area of 300 acres, and the whole of it, with the exception of thirty acres which were subsequently given up to Bishop Middleton for an English college, still continues under cultivation as a botanic garden. Kyd died in 1793, and in the same year his place as superintendent of the garden was taken by Dr. William Roxburgh, a young botanical enthusiast, and one of Koenig's "United Brotherhood." Roxburgh had studied botany in Edinburgh, where he was a favourite pupil of Dr. Hope. Desirous of seeing something of foreign countries, he made several voyages to Madras in ships belonging to the Honourable East India Company. In 1776 he accepted an appointment in the Company's medical establishment, and was posted to the town of Madras, where he very soon made the acquaintance of Koenig. Roxburgh was shortly after transferred to a remote district, a good deal to the north of Madras, then named the Northern Circars. The station of Samulcotta, which formed Roxburgh's headquarters during his sojourn in the Circars, stands on the edge of a hilly region possessing a very interesting flora, and this flora he explored with the greatest ardour; and, as part of the result of his labours, an account of some of the most interesting of its plants was published in London, at the East India Company's expense, in three large folio volumes, under the title, "The Plants of the Coast of Coromandel." This was Roxburgh's earliest publication on a large scale. The first part of this book appeared in 1795, and the last not until 1819, *i.e.* five years after the author's death. The increased facilities afforded to Roxburgh after his transfer to a comparatively well-equipped institution like that at Calcutta induced him at once to begin the preparation of descriptions of all the plants indigenous to British India of which he could procure specimens. And so diligently did he work that, when he was finally driven from India by ill-health in 1813, he left complete and ready for publication the manuscripts of his "Flora Indica" and of his "Hortus Bengalensis" (the latter being an enumeration of the plants in cultivation in the Calcutta garden). He also left admirable coloured drawings (mostly of natural size) of 2533 species of plants indigenous to India. Seldom have twenty years yielded so rich a botanical harvest! Dr. Roxburgh was thus the first botanist who attempted to draw up a systematic account of the plants of India, and his book, which is on the Linnæan system, is the basis of all subsequent works on Indian botany; and until the publication of Sir Joseph Hooker's monumental "Flora of British India," it remained the only single book through which a knowledge of Indian plants could be acquired. Roxburgh was immediately succeeded in the Calcutta garden by Dr. Buchanan-Hamilton, a man of many accomplishments, who had travelled from Nepal in the North to Ava and Mysore in the South, accumulating materials for a gazetteer of the Honourable Company's possessions. Dr. Buchanan was a zoologist as well as a botanist. He had published a valuable account of Mysore, Canara and Malabar, and had collected materials for a work on the Fishes of India, besides having accumulated a large herbarium, part of which may now be consulted at the University of Edinburgh. Prior to his death Buchanan-Hamilton had begun to write a learned commentary on Van Rheede's "Hortus Malabaricus." Many of his Nepalese collections were described in 1825 (a few years before his own death) by Don in his "Prodromus Floræ Nepalensis." Buchanan-Hamilton remained only one year at Calcutta, and in 1815 he was succeeded by Nathaniel Wallich, a native of Copenhagen, who, prior to his appointment to the Calcutta garden, had been attached to the Danish settlement at Serampore, twenty miles higher up the Hooghly. Wallich remained superintendent of the Calcutta garden for thirty years. In 1846 he went to England, and in 1854 he died. During his tenure of office in the Calcutta garden, Wallich organised collecting expeditions to the then little-known regions of Kamaon and Nepal (in the Himalaya), to Oudh, Rohilcund, Sylhet, Tenasserim, Penang, and Singapore. He undertook, in fact, a botanical survey of a large part of the Company's possessions in India. The vast materials thus collected under his own immediate direction, and the various contributions made by others, were taken to London by him in 1828. With these were subsequently incorporated the collections of Russell, Klein, Heyne, Rottler, Buchanan-Hamilton, Roxburgh, and Wight. And by the help of a band of distinguished European botanists, among whom may be named De Candolle, Kunth, Lindley, Meissner, Nees von Esenbeck, Von Martius and Bentham (the latter in a very special manner), this vast mass of material was classified and named specifically. A catalogue of the collection was prepared by Wallich himself (largely aided by Bentham), and sets of the named specimens were distributed to the leading botanical institutions in Europe, every example of each species bearing the same number. No description of the whole collection was ever attempted, but many of the plants belonging to it were subsequently described in various places and at various times. So extensive was the Wallichian distribution that, amongst the names and synonyms of tropical Asiatic plants, no citation is more frequent in botanical books than that of the contraction "Wall. Cat." Besides the naming and distribution of this gigantic collection, Wallich prepared and published, at the expense of the same liberal and enlightened East India Company, his "Plantæ Asiaticæ Rariores," in three folio volumes with 300 coloured plates. He also contributed to an edition of Roxburgh's "Flora Indica," which was begun by the celebrated Dr. Carey of Serampore, descriptions of many plants of his own collecting. But the task of publishing his discoveries in this way proved beyond his powers, as it would have proved beyond those of any one who had only 365 days to his year, and less than a hundred years as his term of life! Carey and Wallich's edition of Roxburgh's "Flora Indica" was brought to an untimely conclusion at the end of the *Pentandria Monogynia* of Linnæus. Wallich also began an illustrated account of the flora of Nepal under the title, "Tentamen Floræ Nepalensis." But this also came to a premature end with the publication of its second part.

During much of the time that Wallich was labouring in Northern India, Robert Wight, a botanist of remarkable sagacity and of boundless energy, was labouring in Southern India, chiefly in parts of the Peninsula different from those in which Koenig and his band had worked. Wight was never liberally supported by the Government of Madras, and it was mostly by his own efforts and from his own resources that his collections were made and that his botanical works were published. The chief of the latter is his "Icones Plantarum." This book consists of figures with descriptions of more than two thousand Indian species. A good many of the plates are indeed copies

from the suite of drawings already referred to as having been made at Calcutta by Dr. Roxburgh. The rest are from drawings made, either by native artists under his personal supervision, or by his own hands. Ample evidence of the extraordinary energy of Dr. Wight is afforded by the facts that, although he had to teach the native artists whom he employed both to draw and to lithograph, the two thousand *Icones* which he published and described were issued during the short period of thirteen years, and that during the whole of this time he performed his official duties as a medical officer.

Besides this *magnum opus*, Wight published his *Spicilegium Nilghirense* in two vols. quarto, with 200 coloured plates. And between 1840 and 1850 he issued in two vols. quarto, with 200 plates, another book named "Illustrations of Indian Botany," the object of which was to give figures and fuller descriptions of some of the chief species described in a systematic book of the highest botanical merit, which he prepared conjointly with Dr. J. Walker-Arnot, Professor of Botany in the University of Glasgow, and which was published under the title "Prodromus Floræ Peninsulæ Indicæ." The "Prodromus" was the first attempt at a flora of any part of India in which the natural system of classification was followed. Owing chiefly to the death of Dr. Walker-Arnot, this work was never completed, and this splendid fragment of a flora of Peninsular India ends with the natural order *Dipsaceae*.

The next great Indian botanist whose labours demand our attention is William Griffith. Born in 1810, sixteen years after Wight, and twenty-four years later than Wallich, Griffith died before either. But the labours even of such devotees to science as were these two are quite eclipsed by those of this most remarkable man. Griffith's botanical career in India was begun in Tenasserim. From thence he made botanical expeditions to the Assam valley, exploring the Mishmi, Khasia and Naga ranges. From the latter he passed by a route never since traversed by a botanist, through the Hookung valley down the Irrawadi to Rangoon. Having been appointed, soon after his arrival in Rangoon, surgeon to the Embassy to Bhotan, he explored part of that country and also part of the neighbouring one of Sikkim. At the conclusion of this exploration he was transferred to the opposite extremity of the Northern frontier, and was posted to the Army of the Indus. After the subjugation of Cabul, he penetrated to Khorassan. Subsequently he visited the portion of the Himalaya of which Simla is now the best-known spot. He then made a run down the Nerbudda valley in Central India, and finally appeared in Malacca as Civil Surgeon of that Settlement. At the latter place he soon died of an abscess of the liver brought on by the hardships he had undergone on his various travels, which were made under conditions most inimical to health, in countries then absolutely unvisited by Europeans. No botanist ever made such extensive explorations, nor himself collected so many species (9000) as Griffith did during the brief thirteen years of his Indian career; none ever made so many field notes or wrote so many descriptions of plants from living specimens. His botanical predecessors and contemporaries were men of ability and devotion. Griffith was a man of genius. He did not confine himself to the study of flowering plants, nor to the study of them from the point of view of their place in any system of classification. He also studied their morphology. The difficult problems in the latter naturally had most attraction for him, and we find him publishing, in the *Linnaean Transactions*, the results of his researches on the ovule in *Santalum*, *Loranthus*, *Viscum*, and *Cycas*. Griffith was also a cryptogamist. He collected, studied, and wrote much on Mosses, Liverworts, *Marsiliaceae*, and Lycopods, and he made hundreds of drawings to illustrate his microscopic observations. Wherever he travelled he made sketches of the most striking features in the scenery. His habit of making notes was inveterate; and his itinerary diaries are full of information, not only on the botany, but also on the zoology, physical geography, geology, meteorology, archæology and agriculture of the countries through which he passed. His manuscripts and drawings, although left in rather a chaotic state, were published after his death under the editorship of Dr. McClelland, at the expense of the enlightened and ever-liberal East India Company. They occupy six volumes in octavo, four in quarto, and one (a "Monograph of Palms") in folio.

Another botanist of much fame, who died prematurely in 1822, after an Indian career of only nine years, was William Jack. In 1814–15, Jack accompanied Ochterlony's army to the Nepal terai. He was transferred in 1818 to the Company's settlement in Sumatra under Sir Stamford Raffles, and during the four years of his residence in Sumatra he contributed to botanical literature descriptions of many new genera and species which were published in his "Malayan Miscellanies." His collections, unfortunately, were for the most part lost by an accident, but those which were saved are now in the Herbarium Delessert in Geneva.

Somewhat similar to Griffith in temperament and versatility was the brilliant Victor Jacquemont, a French botanist who, at the instance of the Paris Natural History Museum, travelled in India for three years from 1829 to 1832. During this period Jacquemont collected largely in the Gangetic plain. He then entered the North-west Himalaya at Mussourie, explored Gharwal and Sirmur, ascended the Sutlej to Kanawer and Piti (at that time unexplored), visited Cashmir, and returning to the plains, crossed Northern Rajputana to Malwa and the Deccan. He finally reached Bombay with the intention of returning to France. But at Bombay he succumbed to disease of the liver, brought on by hard work and exposure. His remains, after having lain in the cemetery there for fifty years, were, with that tender regard for the personality of her famous sons which France has always shown, exhumed in 1881, and conveyed in a French frigate to find a permanent resting-place in the place of Jacquemont's birth. Jacquemont's collections were transmitted to Paris, and his plants were described by Cambessedes and Decaisne, while his non-botanical collections were elaborated by workers in the branches of science to which they respectively appertained, the whole being published in four volumes quarto, at the expense of the French Government.

The roll of eminent botanists who worked in India during the first half of the century closes with the name of Thomas Thomson, who collected plants extensively between 1842 and 1847 in Rohilkund and the Punjab, and again still more extensively during a Government mission to the North-west Himalaya and Tibet which was continued from 1847 to 1849. During this period Dr. Thomson explored Simla, Kanawar, Piti, Cashmir, Ladak, and part of the Karakoram. His collections, which were large and important, were transmitted to the Botanic Garden at Calcutta, and thence in part to Kew. They formed no insignificant part of the materials on which the "Flora Indica" and "Flora of British India" were founded. Dr. Thomson also published an account of his travels—an admirable book, though now jostled out of memory by the quantities of subsequently issued books of Himalayan travel and adventure.

About the year 1820 a second centre of botanical enterprise was established at Seharunpore, in the North-west Provinces. A large old garden near that important town, which had been originally founded by some Mahommedan nobles of the Delhi Court, was taken over by the Honourable Company, and was gradually put upon a scientific basis by Dr. George Govan, who was appointed its first superintendent. Dr. Govan was in 1823 succeeded by Dr. J. Forbes Royle, and he in 1832 by Dr. Hugh Falconer. Dr. Royle made collections in the Jumno-Gangetic plain, in the Lower Gharwal Himalaya, and in Cashmir. He was distinguished in the field of economic rather than in that of systematic botany, his chief contribution to the latter having been a folio volume entitled "Illustrations of the Botany of the Himalaya Mountains." His valuable labours as an economic botanist will be noticed later on. Hugh Falconer was an accomplished palæontologist who devoted but little of his splendid talents to botany. His great contribution to palæontology, the value of which it is almost impossible to over-estimate, consisted of his exploration and classification of the tertiary fossils of the Sewalik range. Falconer was transferred to the Calcutta Garden in 1842. He was succeeded at Seharunpore by Dr. W. Jameson, who explored the botany of Gharwal, Kamaon and Cashmir, but who published nothing botanical, his chief energies having been devoted to the useful work of introducing the cultivation of the China tea plant into British India, and this he did (as will afterwards be mentioned) with triumphant success.

During the first half of the century a considerable amount of excellent botanic work was done in Western India by Graham, Law, Nimmo, Gibson, Stocks and Dalzell, the results of whose labours culminated in the preparation by Graham of a list of the plants of Bombay, which was not, however, published until 1839 (after his death); in the publication by Stocks of various papers on the botany of Scinde; and in the publi-

cation by Dalzell in 1861 of his "Flora of Bombay." It is impossible in a brief review like the present to mention the names of all the workers who, in various parts of the gradually extending Indian Empire, added to our knowledge of its botanical wealth. It must suffice to mention the names of a few of the chief, such as Hardwicke, Madden, Munro, Edgeworth, Lance and Vicary, who collected and observed in Northern India, and who all, except the two last mentioned, also published botanical papers and pamphlets of more or less importance; Jenkins, Masters, Mack, Simons and Oldham, who all collected extensively in Assam; Hofmeister, who accompanied Prince Waldemar of Prussia, and whose collections form the basis of the fine work by Klotsch and Garcke (*Reis. Pr. Wald.*); Norris, Prince, Lobb and Cuming, whose labours were in Penang and Malacca; and last, but not least, Strachey and Winterbottom, whose large and valuable collections, amounting to about 2000 species, were made during 1848 to 1850 in the higher ranges of the Kamaon and Gharwal Himalaya, and in the adjacent parts of Tibet. In referring to the latter classic Herbarium, Sir Joseph Hooker remarks that it is "the most valuable for its size that has ever been distributed from India." General Strachey is the only one who survives of the splendid band of collectors whom I have mentioned. I cannot conclude this brief account of the botanical labours of our first period without mentioning one more book, and that is the "Hortus Calcuttensis" of Voigt. Under the form of a list, this excellent work, published in 1845, contains a great deal of information about the plants growing near Calcutta, either wild or in fields and gardens. It is strong in vernacular names and vegetable economics.

(*To be continued.*)

MATHEMATICS AT THE BRITISH ASSOCIATION.

THE visit of the French Association to Dover necessitated some departures from the usual programme of the British Association week, and the mathematical meeting was held this year on Monday, September 18. Prof. Forsyth, of Cambridge, presided over a well-filled room.

The session opened with the formal communication of two reports of committees: the first, drawn up by Prof. Karl Pearson, and practically forming a continuation of a previous report, contains a set of tables of certain functions connected with the integral

$$G(r, \nu) = \int_0^\pi \sin^r\theta e^{\nu\theta} d\theta,$$

for integral values of r from 1 to 50, and for values of ν at certain intervals from 0 to 1. These functions are of importance in certain statistical problems.

The second report consists substantially of the new "Canon Arithmeticus" which Lieut.-Colonel Cunningham has prepared; the Association has made a grant for publishing the tables as a separate volume (they cannot well be fitted into the comparatively small page of the B.A. Report), and it is to be hoped that before long they will become generally available for workers in the Theory of Numbers.

The first of the papers was read by Dr. Francis Galton, on "The Median Estimate." Dr. Galton proposes to substitute a scientific method for the very unsatisfactory ways in which the collective opinion of committees and assemblies of various kinds is ascertained, in respect to the most suitable amount of money to be granted for any particular purpose. How is that medium amount to be ascertained which is the fairest compromise between many different opinions? An average value—*i.e.* the arithmetic mean of the different estimates—may greatly mislead, because a single voter is able to produce an effect far beyond his due share by writing down an unreasonably large or unreasonably small sum. Again, few persons know what they want with sufficient clearness to enable them to express it in numerical terms, from which alone an average may be derived; much deeper thought-searching is needed to enable a man to make such a precise affirmation as that "in my opinion the bonus to be given should be 80*l.*," than to enable him to say "I do not think he deserves so much as 100*l.*, certainly not more than 100*l.*"

Dr. Galton's plan for discovering the medium of the various sums desired by the several voters is to specify any two reasonable amounts A and B, and to find what percentage a of voters think that the sum ought to be less than A, and what percentage b vote for less than B. It may now be assumed that the estimates will be distributed on either side of their (unknown) *median* m, with an (unknown) quartile q, in approximate accordance with the normal law of frequency of error; and thus (using the table of centiles given in the author's "Natural Inheritance") the required median value can be found.

This was followed by a paper "On a system of invariants for parallel configurations in space," by Prof. Forsyth. The process followed by the author is one in which English mathematicians have always excelled—namely, the deduction of difficult analytical results from simple geometrical considerations. Prof. Forsyth's final formulæ may be regarded as invariantive relations between certain definite integrals; the way in which he finds them is as follows:—

Consider any plane curve; if we suppose a circle of constant size to roll on the curve, its envelope will be another curve, which is said to be *parallel* to the original one. If now L be the length and A the area of a curve, it is found that the quantity $A - \frac{1}{4\pi}L^2$ has the same value for the parallel as for the original curve; in other words,

$$A - \frac{1}{4\pi}L^2$$

is *invariantive* for parallel curves. Similarly in space of three dimensions, the envelope of a sphere of fixed size which rolls on a given surface is another *parallel* surface; and if V be the volume contained by a surface, S its superficial area, and L twice the surface-aggregate of the mean of the curvatures at any point, then it is found that the quantities

$$S - \frac{1}{16\pi}L^2 \text{ and } V - \frac{1}{8\pi}LS + \frac{1}{192\pi^2}L^3$$

are invariantive for all parallel surfaces.

Similar results hold for space of n dimensions. At the end of the paper the expressions obtained are shown to be connected with the ordinary invariant-theory of binary forms.

The next paper, read by Prof. Everett, was concerned with "The Notation of the Calculus of Differences." In conjunction with the ordinary symbol Δ, defined by

$$\Delta y_n = y_{n+1} - y_n,$$

Prof. Everett employs another symbol δ, defined by

$$\delta y_n = y_n - y_{n-1},$$

so that

$$\delta = \Delta_{1+}\Delta.$$

The use of δ simplifies some of the well-known formulæ of the calculus of finite differences.

Prof. A. C. Dixon, of Galway, followed, with a paper "On the Partial Differential Equation of the Second Order." Let z be the dependent, and x and y the independent, variables; and with the usual notation, let

$$p = \frac{\partial z}{\partial x}, \quad q = \frac{\partial z}{\partial y}, \quad r = \frac{\partial^2 z}{\partial x^2}, \quad s = \frac{\partial^2 z}{\partial x \partial y}, \quad t = \frac{\partial^2 z}{\partial y^2},$$

and consider the differential equation

$$f(x, y, z, p, q, r, s, t) = 0.$$

This may be supposed solved by using two more relations

$$u = a, \quad v = b,$$

among the quantities x, y, z, p, q, r, s, t, to give values of r, s, t, which, when substituted in

$$dz = pdx + qdy, \qquad dp = rdx + sdy, \qquad dq = sdx + tdy,$$

render these three equations integrable. This will not be possible, of course, unless the expressions u, v, fulfil certain conditions. Prof. Dixon considers the case in which u can be so determined that v is only subjected to one condition, and finds that then du is a linear combination of the differential expressions used in Hamburger's method of solution. If such a function u can be found, the system $f=0$, $u=a$, will have a series of solutions depending on an arbitrary function of one variable, and involving two further arbitrary constants.

The next paper, "On the Fundamental Differential Equations of Geometry," was read by Dr. Irving Stringham, of the University of California. Dr. Stringham derives the analytical formulæ for non-Euclidian Geometry by following a procedure indicated by Feye St. Marie, and later discussed in Killing's "Nicht-Euclidischen Raumformen." Within an infinitesimal domain in non-Euclidian space, the propositions of Euclidian