had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this Border Land, and even beyond; here, it seems to me, lie Ultimate Realities, subtle, far-reaching, wonderful.

"Yet all these were, when no Man did them know,
Yet have from wisest Ages hidden beene;
And later Times thinges more unknowne shall show.
Why then should witlesse Man so much misweene,
That nothing is, but that which he hath seene?"

THE BRITISH ASSOCIATION

GENERAL satisfaction is expressed with the Sheffield meeting. The people of the town and district did their best, amid many difficulties, to give the members of the Association a hearty reception, and they succeeded. The excursions on Thursday were well attended, and those who took part in them seem to have enjoyed themselves. At the meeting of the General Committee, Swansea was selected as next year's place of meeting, with Prof. A. R. Ramsay as president; the date of meeting is August 25. A letter was read from the Archbishop of York, warmly urging upon the Association to meet in the archiepiscopal City in 1881, when, for some unaccountable reason, the jubilee is to be celebrated, as we have already said, in the fifty-first year of the Association's existence. As the result of the important discussion in Section F on science teaching in schools, a committee was appointed for the purpose of reporting, in addition to other matters, whether it is important that her Majesty's inspectors of elementary schools should be appointed with reference to their ability for examining on scientific specific subjects of the code, the committee to consist of Mr. Mundella, M.P., Mr. Shaw, Mr. Bourne, Mr. Jas. Heywood, Mr. Wilkinson, and Dr. J. H. Gladstone.

REPORTS

Report of the Committee on Erratic Blocks, presented by the Rev. H. W. Crosskey, F.G.S. (Abstract.)

Several contributions of interest and importance have been received respecting the position and distribution of erratic blocks.

A granite boulder 3 × 2·5 × 2 feet has been found by Mr. Hall, in the village of Bickington, parish of Fremington. There is no similar rock nearer than Lundy Island, twenty-five miles west-north-west from the boulder and Dartmoor, twenty-five miles south by east. Its height above the sea is 80 feet.

Among the most remarkable erratic blocks yet described in the midland district, are those reported upon Frankley Hill, at a height of 650 feet above the sea. They were examined by the writer in company with Prof. T. G. Bonney, and the following is a summary of the observations made:—

A section of drift beds is exposed in a cutting of the new Hales Owen Railway passing through Frankley Hill. The section is as follows:—Permian clay, sand of clayey texture, yellowish sand, greyish sandy clay with brinter pebbly clay, somewhat sandy. The heights of the clays and sands are very irregular throughout the section which is in itself about 60 feet in depth.

Fragments of permian sandstone (which is exposed in a part of the section) are scattered through the sands and clays, but erratic blocks are rare. Indeed, one only—a green-stone—was noticed in the cutting itself, although others doubtless occur.

No part of this section can be called a "boulder clay"—if by "boulder clay" be meant either a clay formed beneath land ice, or a clay carried away by an iceberg and deposited on the sea-bottom, as the berg melted or stranded.

The various sands and gravels have all the appearance of being a "wash" from older beds, effected during the depression and subsequent upheaval of the present land surface. They are neither compactly crowded with erratics, nor are fragments of local rocks heaped irregularly together, and grooved and striated. The way in which the pieces of native rock are scattered through the beds, does not indicate any other force than that which would be exerted by the ordinary "wash" of the waters during the movements just mentioned.

The presence of a few erratics shows that the *wash* must have taken place beneath the waters of a glacial sea, over which icebergs floated.

These beds appear to have been formed in the earlier rather than the later part of the glacial epoch. In a field *on the summit of the section* a large number of erratics are to be seen which have been taken from a recent surface-drain. Twenty of these boulders are felsite, two are basalt, one is a piece of vein-quartz, and one is a Welsh diabase. They constitute a group of allied rocks, evidently from one district. Probably they belong to the great Arenig dispersion. Two of the felsites close to the group are of considerable size, the larger being about 6 × 4 × 2 feet. Similar blocks may be traced to the summit of the hill. One felsite boulder opposite the Yew Trees is about 4·5 × 3 × 2 feet, and is partly buried in the ground.

The height of the boulders above the sea is remarkable, their highest level being 650 feet.

This indicates a corresponding depression of the land, since no Welsh glacier could have travelled over hill and down dale to this summit-level. To render any such glacier work conceivable, the Welsh mountains must have stood at a height beyond any point for which there is the slightest evidence.

This group of boulders on Frankley Hill appears to have been dropped by an iceberg travelling from Wales upon the top of the clays and sands exposed in the railway cutting at a time when the land was depressed at least 700 feet. In the clays and sands upon which the summit group of erratics rests, we must have beds belonging to an earlier date than the *close* of the glacial epoch; and the erratics in the cutting must be discriminated from those left at the higher level.

Some remarkable boulders were described from the neighbourhood of Wolverhampton: (1) a striated boulder of felsite 11 × 3 × 3 feet; (2) one of slate, broken into two parts, but which, when whole, measured 11·25 × 6·25 × 3·5 feet; (3) one of granite about 4·75 feet in each dimension, and weighing about three tons.

Mr. D. Mackintosh traces the origin of the so-called "greenstone" boulders (more properly to be called diorites or dolerites) around the estuaries of the Mersey and the Dee.

The area in which they are very much concentrated is intensely striated, and nearly all the striæ point divergently to the south of Scotland, *i.e.*, between N. 15° W. and N. 45° W.

A large "greenstone" boulder has been found at Crosby, resting on a perfectly flat glaciated rock surface, with striæ pointing N. 40° W.

Additional presumptions in favour of the Scottish derivation of these boulders may be found (1) in the fact that nearly all these boulders consist of basic rocks similar to some found in the south of Scotland, and (2) in the extent to which they are locally concentrated on the peninsula of Wirral and the neighbouring part of Lancashire. Many fresh greenstone boulders have been lately exposed in the newest Bootle Dock excavation. The largest is 6 × 4·5 × 3 feet, and was found on the surface of the upper boulder clay. As a rule these boulders are excessively flattened and regularly grooved.

Mr. J. R. Dakyns describes the occurrence of Shap granite boulders on the Yorkshire coast. There are several at Long Nab on the north side of the Nab; one of these measures 3 cubic feet. Others are on the north side of Cromer Point; south of Cromer Point there are more till you come nearly to Filey. There is one measuring 3 × 2·5 × 2 feet on the top of the cliff about a mile from Filey. It is probably practically undisturbed, for the ground slopes inland from the cliff, and therefore, if it has been turned up in ploughing and moved, it cannot have been moved far, for no one would take the trouble to cart a huge boulder far up-hill.

There are several boulders of Shap granite on the shore along the north of Filey Bay, but none along the south till one reaches Flamborough Head. Several occur along the shore between Flamborough Head and Flamborough south landing; one of these measures 36 cubic feet. One may be seen rather more than a mile south of Bridlington Quay, and doubtless they have travelled still further south, since there is one built into a wall at Hornsea.

The destruction of erratic blocks is going on so rapidly that the Committee invite continued contributions of information concerning them.

Report of the "Geological Record" Committee, by W. Whitaker, B.A., F.G.S.—Since the last meeting of the Association the third volume of the "Geological Record" has been published. This gives an account of books, papers, &c., on geology, mineralogy, and palæontology published at home and abroad during the year 1876. The fourth volume (for 1877) is in the press; and part of the MS. for the fifth volume (for 1878) is in hand. The average size of the three published volumes is 440 pages, each volume recording over 2,000 papers, &c.

Fifteenth Report of the Committee for Exploring Kent's Cavern, Devonshire. Drawn up by W. Pengelly, F.R.S.—Work during the past year has been carried on in the "High Chamber" and its branches. This chamber extends for about 53 feet in a north-westerly direction from the "Cave of Inscriptions." At its inner or north-western end it sends off two branches; the northern branch was excavated for about 12 feet, when the work was abandoned, as breccia, blocks of limestone, and crystalline stalagmite reached the roof and rendered further progress difficult and expensive. The "High Chamber" contains only breccia, the oldest mechanical deposit in the cavern, and the crystalline stalagmite which overlies it. Bones of bears and implements have been found in the breccia here, and some recent objects were found on or near the surface. The southern branch of the High Chamber is called the "Swallow Gallery," from a swallow-hole which occurs about 18 feet from the entrance. This has been explored for about 50 feet. It also contains only breccia, generally lying bare, but covered with crystalline stalagmite at the inner part of the chamber. Here too the remains consist chiefly of bear; a few implements have also been found. There were entrances to the cavern by the Swallow Gallery and through the swallow holes; but these were quite closed before the beginning of the "cave-earth era," and have since remained so. Excavations have also been made in Clinnick's Gallery; but here, as in former years, the number of "finds" has been small.

Prof. A. Leith Adams has availed himself of the collection of mammoth remains made during several years from Kent's Cavern, to illustrate his memoir for the Palæontological Society on "British Fossil Elephants." Extracts from this memoir are given in the report, and especial mention is made of a molar found in 1874 in the "Cave of Rodentia." Prof. Adams says:—"This tooth is one of the smallest milk-molars of any elephant with which I am acquainted, and is even more diminutive than the first milk-teeth of the Maltese pigmy elephants."

Report on the Miocene Flora, &c., of the North of Ireland, by W. H. Baily.—The plants occur, between two beds of basalt, in a deposit of brown and red bole, and immediately overlying a bed of pisolitic iron ore, which has been extensively worked. Twenty-five species of plants have been determined; they are most closely allied to the fossil flora of North Greenland, some of the forms also occurring at Bovey Tracy.

Sixth Report of a Committee consisting of Professors Herschel and Lebour, and Mr. J. T. Dunn, to determine the Thermal Conductivities of certain Rocks, showing especially the Geological Aspects of the Investigation.—The research and correspondence which it would require to complete a historical sketch of the attempts already made to determine by experiments the thermal conductivities of the most widely distributed terrestrial rocks, which the Committee proposed to prepare during the past year, are not so far advanced at present as to allow them to be comprehended in this year's Report. But the Committee hopes during the coming year by continuing its inquiries with the addition to its numbers of the names of Professors W. E. Ayrton and J. Perry, of the Imperial College of Engineering in Japan, to carry out the object of its undertaking, so as to exhibit the state of our knowledge of the data of thermal conductivity of those widespread kinds of rock which constitute the external materials of the globe.

The Committee has obtained during the past year some measurements of thermal conductivities both of rocks and ebonite, and india-rubber, and corroborates the very low value found by Prof. Stefan, of Vienna, for the conductivity of ebonite. It has also corrected some imperfections of its former tables, by showing that the values given in them have throughout been described too low, by about an eighth of their assigned values, and find that with this correction their results have been in close accordance with the measures that Sir William Thomson and other observers deduced of the conductivities of soils and rocks in places where underground thermometers have been sunk and read regularly for many years. The records of such thermometers in the grounds of the Royal Observatory at Greenwich have been preserved continuously for more than thirty years, and the last volume of "Greenwich Meteorological Reductions" contains the observations of their temperatures for twenty-seven successive years, 1847-73. This record (already used in part by Prof. Everett) might now afford a new and very valuable determination of the conductivity of sand and gravel strata, such as make up the materials of Greenwich Hill, upon which the Royal Observatory is placed.

Report of the Committee, consisting of Prof. Sir William Thomson, Prof. Clerk-Maxwell, Prof. Tait, Dr. C. W. Siemens, Mr. F. J. Bramwell, and Mr. J. T. Bottomley for commencing Secular Experiments upon the Elasticity of Wires, by J. T. Bottomley.—At the last meeting of the British Association, the arrangements for suspending wires for secular experiments in the tube which has been erected in the tower of the Glasgow University Buildings, and for observing these wires, were described and reported as complete. Some improvements have since been found necessary; but, so far as these are concerned, there is not much to add to the report then given.

The long iron tube has been closed at the top and bottom so as to keep out currents of air and dust, and the joints of the tube have been carefully caulked.

Some improvements in the cathetometer used for observing the marks on the wires were also found to be required, but the instrument is now satisfactory.

Six wires have now been suspended in the tube; their stretching weights have been attached to them, and they have been carefully marked and measured. These wires are suspended in pairs—two of gold, two of platinum, and two of palladium. One of each of the pairs is loaded with a weight equal to one-twentieth of its breaking weight, and the other of each pair with a weight equal to one-half of its breaking weight. The points of suspension for each pair are very close together, so that any yielding of the place of support affects both wires equally.

Each wire is marked with paint marks, and there are other marks on the wires and on the weights attached to them where positions have been determined. These marks are described in a laboratory book which is at present kept in the room of the professor of natural philosophy in the University of Glasgow. The measurements that have been made, and the experiments that have been undertaken in connection with the work assigned to the Committee, are all being entered in this book. This, however, can only be regarded as a temporary mode of keeping these records.

It is intended that the record in this book shall contain—

1. Description of the tube and arrangements for suspending the wires, and for suspending additional wires at future times, and description of the mode of attachment of the stretching weights.
2. Description of the cathetometer and method of measuring the changes, should there be any, in the lengths of the wires.
3. Description of the wires themselves, and record of experiments that have already been made on them as to breaking weight and Young's modulus of elasticity.
4. Description of the marks put on the wires, and record of the measurements that have been made as to the lengths of the wires and as to the relative positions of the marks at the time of suspending the wires.

The stretching weight and the clamps attached to the wires are engraved each with the amount of its weight in grammes. The measurements are all made in grammes and centimetres.

It seems desirable, considering the nature of the experiments that are just now commencing, that information regarding them should be preserved to the British Association in some appropriate way; and that provision should be made for recording every change that may take place, and for communicating from time to time to the Association such information as may be obtained.

In the report presented to the Association by this Committee last year, it was mentioned that experiments had been commenced in the laboratory of the University of Glasgow in connection with the present investigation on the effects of stress maintained for a considerable time in altering the elastic properties of various wires. These experiments are still being carried on, and results of interest and importance have been already arrived at.

The most important of these experiments form a series that have been made on the elastic properties of very soft iron wire. The wire used was drawn for the purpose, and is extremely soft and very uniform. It is about No. 20 B.W.G., and its breaking weight, tested in the ordinary way, is about 45 lbs. This wire has been hung up in lengths of about 20 feet, and broken by weights applied, the breaking being performed more or less slowly.

In the first place, some experiments have been tried as to the smallest weight which, applied very cautiously and with precautions against letting the weight run down with sensible velocity, will break the wire. These experiments have not yet been very satisfactorily carried out, but it is intended to complete them.

The other experiments have been carried out in the following way:—It was found that a weight of 28 lbs. does not give permanent elongation to the wire taken as it was supplied by the wire drawer. Each length of the wire, therefore, as soon as it was hung up for experiment, was weighted with 28 lbs., and this weight was left hanging on the wire for 24 hours. Weights were then added till the wire broke, measurements as to elongation being taken at the same time. A large number of wires were broken with equal additions of weight, a pound at a time, at intervals of from three to five minutes—care being taken in all cases, however, not to add fresh weight if the wire could be seen to be running down under the effect of the weight last added. Some were broken with weights added at the rate of one pound per day, some with three-quarters of a pound per day, and some with half a pound per day. One experiment was commenced in which it was intended to break the wire at a very much slower rate than any of these. It was carried on for some months, but the wire unfortunately rusted, and broke at a place which was seen to be very much eaten away by rust, and with a very low breaking weight. A fresh wire has been suspended, and is now being tested. It has been painted with oil, and has now been under experiment for several months.

The following tables will show the general results of these experiments. It will be seen, in the first place, that the prolonged application of stress has a very remarkable effect in increasing the strength of soft iron wire. Comparing the breaking weights for the wire quickly broken with those for the same wire slowly broken, it will be seen that in the latter case the strength of the wire is from two to ten per cent. higher than in the former, and is on the average about five or six per cent. higher. The result as to elongation is even more remarkable, and was certainly more unexpected. It will be seen from the tables that, in the case of the wire quickly drawn out, the elongation is on the average more than three times as great as in the case of the wire drawn out slowly. There are two wires for which the breaking weights and elongations are given in the tables, both of them "bright" wires, which showed this difference very remarkably. They broke without showing any special peculiarity as to breaking weight, and without known difference as to treatment, except in the time during which the application of the breaking weight was made. One of them broke with 44 lbs., the experiment lasting one hour and a half; the other with 47 lbs., the time occupied in applying the weight being thirty-nine days. The former was drawn out by 28·5 per cent. on its original length, the latter by only 4·79 per cent.

Tables showing the Breaking of Soft Iron Wires at Different Speeds

I.—Wire Quickly Broken

Rate of adding weight.	Breaking weight in pounds.	Per cent. of elongation on original length.
[1] Dark Wire		
½ lb. per minute	45	25·4
1 ,, 5 minutes	45¼	25·9
,, ,, 5 ,, ...	45¼	24·9
,, ,, 4 ,, ...	44¼	24·58
,, ,, 3 ,, ...	44¼	24·88
,, ,, 3 ,, ...	45¼	29·58
,, ,, 5 ,, ...	44¼	27·78
[1] Bright Wire		
1 lb. per 5 minutes	44¼	28·5
,, 5 ,, ...	44¼	27·0
,, 4 ,, ...	44¼	27·1

[1] The wire used was all of the same quality and gauge, but the "dark" and "bright" wire had gone through slightly different processes for the purpose of annealing.

II.—Wire Slowly Broken

Weight added and No. of experiment.	Breaking weight in pounds.	Per cent. of elongation on original length.
1 lb. per day. I.	48	7·58
,, II.	46	8·13
,, III.	47	7·05
,, IV.	47	6·51
,, V.	47	8·62
,, VI.	47	5·17
,, VII.	46	5·50
,, VIII.	47	6·92 Bright wire.
¾ lb. per day. I.	49	8·50
,, II.	48¼	8·81
,, III.	Broken by accident.	
,, IV.	46	7·55
,, V.	46	6·41
,, VI.	45½	6·62
½ lb. per day. I.	48	8·26
,, II.	50	8·42
,, III.	49	7·18
,, IV.	47	4·79 } Bright wires.
,, V.	46½	6·00 }

It was found during the breaking of these wires that the wire becomes alternately more yielding and less yielding to stress applied. Thus, from weights applied gradually between 28 lbs. and 31 or 32 lbs., there is very little yielding and very little elongation of the wire. For equal additions of weight between 33 lbs. and about 37 lbs. the elongation is very great. After 37 lbs. have been put on, the wire seems to get stiff again, till a weight of about 40 lbs. has been applied. Then there is rapid running down till 45 lbs. has been reached. The wire then becomes stiff again, and often remains so till it breaks.

It is evident that this subject requires careful investigation.

Report of the Committee for effecting the Determination of the Mechanical Equivalent of Heat.—The Committee had little to report this year, the work in progress being the protracted one of supplying a means of correcting errors in the determination of the temperature arising from the temporary changes of the fixed points of thermometers constructed of glass. They had learned with pleasure that an extensive series of experiments had recently been made by Prof. H. A. Rowland, of Baltimore, who, being unaware of what had been done by the Committee, had arrived at an equivalent almost identical with that determined by Mr. Joule.

Report of the Committee appointed for the Purpose of endeavouring to procure Reports on the Progress of the Chief Branches of Mathematics and Physics.—Owing to unforeseen circumstances no meeting of this Committee has taken place during the past year. It seems desirable, nevertheless, in order that the question of the reappointment of the Committee may be fully considered, and that there may be a full expression of opinions on the subject referred to it, that a statement should be made to the Section of the proceedings of the Committee, the more so since, in the hope that greater progress would have been made by this time, no report was presented at the last meeting of the Association.

The first matter discussed by the Committee was the character and general plan of the reports which they should endeavour to procure; the next was to what extent or in what manner the production of such reports could be aided by the Committee. Important contributions to the discussion of these questions are contained in written communications to the Committee from two of its members, Professors Clerk-Maxwell and Stokes. Prof. Clerk-Maxwell writes as follows:—

"Reports on special branches of science may be of several different types, corresponding to every stage of organisation, from the catalogue up to the treatise.

"When a person is engaged in scientific research, it is desirable that he should be able to ascertain, with as little labour as possible, what has been written on the subject and who are the best authorities. The ordinary method is to get hold of the most recent German paper on the subject, to look up the references there given, and by following up the trail of each to find out who are the most influential authors on the subject. German papers have the most complete references, because the machinery for docketting and arranging scientific papers is more developed in Germany than elsewhere.

"The *Fortschritte der Physik* gave an annual list of all papers, good and bad, arranged in subjects, with abstracts of the more important ones. Wiedemann's *Beiblätter* is a more select assortment, given more in full.

"I think it doubtful whether a publication of this kind, if undertaken by the British Association, would succeed. Lists of the titles of the proceedings of societies and of the contents of periodicals are given in NATURE. These are useful for strictly contemporary science, and I do not think that a more elaborate system of collection could be kept up for long.

"The intending publisher of a discovery has to examine the whole mass of science to see whether he has been anticipated, but the student wishes to read only what is worth reading. What he requires is the names of the best authors. The selection or election of these is constantly done by skimming individual authors, who indicate by the names they quote the men whose opinions have had most influence. But a report on the history and present state of a science has for its main aim to enumerate the various authors and to point out their relative weight, and this has been very well done in several British Association reports, some of which are nearly as old as the British Association.

"There are some branches of science whose position with respect to the public, or else to the educational interest, is such that treatises or text-books can be published on commercial principles, either as books to be read by the free public, or to be got up by the school public.

"There is little encouragement, however, for a scientific man to write a treatise so long as he can, with much less trouble, produce an original memoir, which will be much more readily received by a learned society than the treatise would have been by a publisher.

"The systematisation of science is therefore carried on under difficulties when left to itself; and I think that the experience of the British Association warrants the belief that its action in asking men of science to furnish reports has conferred benefits on science which would not otherwise have accrued to it.

"There are so many valuable reports in the published volumes that I shall indicate only a few, the selection being founded on the direction of my own work rather than on any less arbitrary principle.

"First, when a branch of science contains abstruse calculations as well as interesting experiments, it is desirable that those who cultivate the experimental side should be conscious that certain things have been done by the mathematicians. The matter to be reported on in this case is not voluminous, but it is hard reading, and those who are not experts require a guide.

"Thus, Prof. Challis in 1834 gave a most useful report on the mathematical investigations by Young, Laplace, Poisson, and Gauss on capillary attraction, and Prof. Stokes in 1862 reports on theories of double refraction. This report may, indeed, be accepted as an instalment of the treatises which, if the desire of the scientific world were law, Prof. Stokes would long ago have written. It is meant, no doubt, as a guide to other men's writings, but it is intelligible in itself without reference to those writings. Such a report is a full justification of the existence of the British Association, if it had done nothing else.

"Another type of report is that of Prof. Cayley on dynamics (1857 and 1862). This seems intended rather as a guide in reading the original authors than as a self-interpreting document, though, of course, besides the criticism and the methodical arrangement, there is much original light thrown on the mass of memoirs discussed in it. It will be many years before the value of this report will be superseded by treatises.

"The report of the Committee on mathematical tables deals with a subject which, though not so abstruse, is larger and dryer than any of the preceding. It is, however, a most interesting as well as valuable report, and supplies information which would never have been printed unless the British Association had asked for the report, and which never would have been obtained if the author of the report had not been available.

"There are several other reports which are not mere reports, but rather original papers preceded by a historical sketch of the subject. No special encouragement is needed to get people to write reports of this kind."

Prof. Stokes thus expresses himself on the subject:—

"It seems to me that reports on the progress of science may be of two kinds, with somewhat different objects in view; and in considering the best mode of meeting these objects, it may be well to keep the distinction in view.

"First, there is a report, the object of which is to prepare a sort of repertorium of what has been done in a particular branch of science since the date of the last report of similar character in the same branch of science.

"A report of this kind should present the reader with a brief account of the leading aim and chief results of the various memoirs which have been published within the time on the branch of science to which it relates; the writer should not be expected to criticise the memoirs, except in plain instances of errors or imperfections, but the responsibility of sifting the wheat from the chaff should in the main be left to the reader.

"Secondly, there are reports of a more comprehensive and far more critical character. These should be made at wider intervals, should take a more comprehensive view of the subject, and should be highly critical, sifting out the substantial acquisitions that had been made to the branch of science to which they refer.

"Each kind of reports are of value, though in somewhat different ways. The first aids the individual in keeping himself up to the progress of science around him—a progress in which from his position he may be expected to take part and to exercise influence. They lighten to him the labour of search, but teach him to exercise his own discrimination.

"The second should be a material aid to the student in making himself master of what was really of value, and help him to avoid wasting his time on what was of little importance, and aid him in judging of the relative importance of different lines of research.

"Reports of the first kind may be much promoted by the work of committees. The division of labour lightens the task, and the feeling of co-operation carries a man through labour which otherwise, as the man is likely to have a good deal else to do, he might hesitate to undertake.

"Reports of the second kind eminently demand the hand of a master, and the hand of a master is not always free. I doubt much if the appointment of committees would aid much in the preparation of *good* reports of this class, and unless reports are thoroughly good they are better, perhaps, not attempted. I do not see what is to be done except to work a good man *when you can get him.*"

It is evident that the distinction here pointed out by Prof. Stokes has an important bearing on the question of the re-appointment of the Committee. The work required for the production of reports intended simply as systematic records "of the leading aim and chief results" of published investigations, would be merely that of careful compilation. It would not only be possible to divide work of this kind among a considerable number of contributors, but to get it done at all such division of labour would be necessary, and accordingly reports of this class could only be furnished by committees. On the other hand, a report which is of the nature of a critical survey of the condition of knowledge in any branch of science, and is intended to indicate the relative value of different investigations, requires to possess a unity of plan and thought which can only result from its being the work of an individual author possessing a complete mastery of his subject. In such a case the function of the committee would be confined to the suggestion of the subject and to requesting some qualified person to report upon it—a function which hitherto has been discharged by the Sectional Committees of the Association.

Report of the Committee, consisting of Prof. Sylvester and Prof. Cayley, appointed for the Purpose of calculating Tables of the Fundamental Invariants of Algebraic Forms.—The valuable services of Mr. F. Franklin, of the Johns Hopkins University, has computed, under Prof. Sylvester's inspection, the *ground forms* (otherwise called the fundamental invariants and covariants) of binary quantics of the 7th, 8th, and 10th orders respectively, thus rendering the list of tables of such forms complete for quantics of all orders up to the 10th inclusive.

The tables of the *Grundformen* of the seventhic and tenthic are published in the *Comptes Rendus de l'Institut*, 1878, 1879; the table of the *Grundformen* of the ninethic in the *American Journal of Mathematics*, March, 1879, and in a future number of that journal will shortly also appear the intermediary tables of the Generating Functions from which such *Grundformen* are deduced.

These tables, in addition to those previously constructed, will, it is believed, form a valuable, and (for the present) a sufficient, basis for the prosecution of this kind of research in what regards the theory of single binary quantics, leaving a wide field still open for computations of a similar nature connected with systems of binary quantics and binary and semi-binary quantics, single or in systems.

Report of the Committee on Atmospheric Electricity in Madeira, by Dr. M. Grabham.—Daily observations in Madeira extremely monotonous, showing very little variation, though suggesting the importance of a station so uniform in weather for the careful observance of diurnal and seasonal changes. The writer, giving himself to the observation of the regular winds and breezes, traces the steady rise of electricity in the early morning to a maximum at 11·30 A.M., which declines after much steadiness for two hours, at first suddenly and then very gradually towards night.

Remarkable fluctuations are noticed during the formation of the maximum which the writer ascribes to masses of cloud on moist air. A description follows of the daily formation of a thin stratum of cloud during fine calm weather which varies slightly in altitude in accordance with temperature and barometric pressure. The electricity below this cloud is always positive and moderately strong. In the cloud itself it is more feeble but of the same sign. Above the cloud at the station where the observation was taken it was very feeble and irregular but always positive. In warmer weather the vapour does not condense into cloud but appears as a blue transparent haze from above, and presents the same electrical indications.

The writer states that all observations in his own garden were vitiated or mitigated by the presence of lofty trees.

The highest potential was observed upon a rock ninety feet high, a few metres from the shore in the Bay of Funchal.

The thinness of the currents of air constituting sea breezes was demonstrated by flying a kite vertically beyond into the true wind blowing in a contrary direction. Abortive attempts were made to bring down the upper electricity through the lower currents. The electricity of the general north-east wind which is identical with the trade wind was found on the heights at the east end to be uniformly moderate and positive.

At the approach of rain-clouds at the termination of a period of fine weather the atmosphere invariably gives increased readings and no negative observations were recorded.

A short description follows of the L'este, a kind of sirocco to which Madeira is occasionally subject and which blows with great force on certain limited mountain districts bringing sand, birds, and other evidence of a distant origin. This wind is extremely dry, in a temperature of 85° the dew points being depressed below freezing. Electrically this wind in its integrity gives no indication of any change whatever except by faint fluctuations about the earth reading.

The writer also notices a very highly electrical condition during the prevalence of L'este wind, of certain clouds which lie quietly among the mountains, though tossed and tumbled on their upper surfaces; he hopes to be able to connect their forms and immobility with their electrical change.

Report of the Committee on Mathematical Tables, by James Glaisher.—In the course of the year the factor table for the fourth million has been printed and stereotyped, and is nearly ready for publication. The manuscript of the factor table for the fifth million is complete. The table for the sixth million is complete as far as the factors entered by the sieves are concerned, but the factors obtained by the multiple method still need entering, and the whole has to be verified. The mode of calculation was described in last year's report, and a more complete account will appear in the introduction to the fourth million. The present report contains the result of the enumeration of the primes in the fourth million, and a list of long sequences of composite numbers occurring in it. The report also contains a table of the first seven Legendrian coefficients, viz., $P^n(x)$ for $n = 1$ to $n = 7$, where

$$P^1(x) = x,\ P^2(x) = \tfrac{1}{2}(3x^2 - 1),\ P^3(x) = \tfrac{1}{2}(5x^3 - 3x),$$
$$P^4(x) = \tfrac{1}{8}(35x^4 - 30x^2 + 3),\ \&c.,$$

each for a hundred values of the argument.

Report of the Committee on Luminous Meteors, by James Glaisher.—After recording the regret the Committee felt at the loss of two of the most active workers—Mr. Greg by his retirement, and Mr. Brooke by death—the report stated that the very unfavourable weather had generally caused only very meagre views of the annual star showers of October, December, January, and April to be seen. The major showers of August had also been hidden from view, owing to the unfavourable weather. The report then dealt in detail with the accounts of conspicuous detonating fire-balls that had occurred in the United States on August 11 and December 18, 1878, and on January 27, 1879; in Bohemia and Saxony on January 12, 1879, and in England on February 22 and 24, 1879, the real paths of all of which had, to a greater or less degree of certainty and closeness, been approximately ascertained. The rest of the report was devoted to a description of the past year's aërolites. The expected return of Biela's comet to its perihelion in the present year, leading a shower of shooting stars to be looked for with much confidence among astronomers on November 27 next, is to be taken advantage of to report next year on meteor showers. As in former years the Committee were under great obligations to Prof. A. S. Herschel for the labour he had bestowed on the report.

Report of the Committee for Calculating Tables of Sun-heat Coefficients, by Rev. Dr. Haughton.—A table showing the total heat received by various latitudes from the sun in the course of a year had been formed; and the work would be completed by next year. The results already obtained have appeared in the *Proceedings* of the Royal Dublin Society.

Report of the Committee consisting of the Rev. H. T. Barnes Lawrence, Mr. Spence Bate, Mr. H. E. Dresser (Secretary), Mr. J. E. Harting, Dr. Gwyn Jeffreys, Mr. J. G. Shaw Lefevre, M.P., Prof. Newton, and the Rev. Canon Tristram, appointed by the Council, for the purpose of Inquiring into the Possibility of Establishing a Close Time for the Protection of Indigenous Animals.—Your Committee has gratefully to acknowledge the resolution of the Council of the Association, whereby your Committee has been not only reappointed but also instructed to report to the Council in case of any action being required. Your Committee begs leave to state that no such emergency as was provided for by this instruction has arisen since the presentation of its last report. Notwithstanding complaints that are occasionally heard, your Committee believes that public opinion continues strongly in favour of the close time principle, as applied to indigenous animals; and on the part of Her Majesty's Government no steps have been taken to carry out the recommendations of the Scottish Herring Fishery Commissioners, upon which your Committee deemed it its duty to animadvert last year. The Bird Preservation Acts, though doubtless evaded in some places, in general appear to work well, and to be enforced without difficulty when occasion requires. Having regard to future contingencies, your Committee ventures to solicit its reappointment with the instructions as to reporting to the Council in case of emergency.

Report of the Committee consisting of Mr. Sclater, Dr. G. Hartlaub, Sir Joseph Hooker, Capt. F. M. Hunter, and Prof. Flower, appointed to take Steps for the Investigation of the Natural History of Socotra.—The Committee have not held any formal meetings, but have been in frequent communication with each other on the subject.

The best time for the exploration of Socotra being from November to March, the Committee were not able to make the necessary arrangements last autumn. Next winter, however, they believe that Col. H. H. Godwin-Austen, than whom no more competent naturalist could be found, will be able to undertake an expedition to Socotra, and to make a thorough investigation of its natural history. Col. Godwin-Austen has applied to the Surveyor-General of India for the use of some of the assistants on his staff, and proposes to make a complete topographical survey of the island during the expedition.

It is estimated that the total cost of the expedition will be about 300*l*. Of this 100*l*. granted by the Association last year, has been received by the Committee and deposited in the London and County Bank at interest. The sum of 175*l*., having been devoted to this same purpose out of the Government Fund of 4,000*l*. administered by the Royal Society, has been paid to Col. Godwin-Austen, and has been added to the account at the London and County Bank.

There remains, therefore, only 25*l*. requisite to complete the sum of 300*l*., which the Committee consider will be required for the expedition.

The Committee request that the Committee for the investigation of the Natural History of Socotra may be re-appointed with the additional name of Col. H. H. Godwin-Austen, and that the balance of 25*l*. necessary to complete the estimate of expenditure may be placed at their disposal.

Report of the Committee on an Instrument for Detecting Fire-damp in Mines, by Prof. G. Forbes.—From the rough model shown last year the Committee had constructed two new instruments, which appeared to them to answer the purpose of measuring the quantity of fire-damp in a coal mine. The one was of a large size, and was worked by an electric battery. The other was small, portable, easily worked, and it answered all the purposes for which it was required. Both instruments were founded upon the facts that sound travels quicker in light gases than in dense ones, and that air which is contaminated with fire-damp is lighter than pure air. The velocity of sound in different qualities of air was compared by noting the lengths which must be given to a brass tube to cause it to resound to a tuning-fork. The accuracy of the instrument was such that the percentage of fire-damp could be determined with an error of considerably less than 1 per cent. On Monday the Committee were enabled to descend the Wharncliffe Silkstone Colliery, in the neighbourhood of Sheffield, by the kindness of the manager, Mr. George Walker, who accompanied them with a number of gentlemen interested in the experiments. This pit was at a depth of 200 yards. Mr. Walker had kindly arranged to stop the ventilation and the pit at the end of the workings. After proceeding for a mile through the galleries they reached this spot, where they hoped to find a large amount of fire-damp. But only a slight quantity was to be found, the Davy lamp generally showing but a feeble blue cap, and the Forbes indicator registering only small percentages. Disappointed here, they were taken by Mr. Walker to another working, where it was thought possible there might be some gas. In a crevice in the roof a flow of gas was found, forming a stratum of light gas. The instrument indicated quantities which gradually increased, as the tube got filled with the air in the crevice, from 14 to 28 per cent. But the small quantity of gas rendered the experiment unsatisfactory, and the Committee were then taken to a disused part of the mine, where it was known there was a blower. Gas in sufficient quantities was found, and the instrument registered gas with more readiness than the Davy lamp. But the greatest quantity registered was 6 per cent., or twelve times the smallest quantity which the indicator detects. There was in the present form of the instrument a difficulty in filling the tube with the air of the place under examination, and the Committee considered that it would be well to alter the instrument so as to obviate the difficulty. From the experiments they could assert that this instrument was capable of detecting and measuring fire-damp even in small quantities.

SECTION A—MATHEMATICAL AND PHYSICAL

On Lightning Protectors for Telegraphic Apparatus, by W. H. Preece.—For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity because the damage done was so insignificant, and because the remedy was found to be worse than the disease. But as telegraph systems increased, as the country became enveloped in one vast network of wires, it was found that the damage done became considerable, until, in fact, about 10 per cent. of the apparatus in use were in one year damaged.

Lightning protectors then became essential. Many forms were tried based on the fact that when a discharge takes place through a non-conductor such as dry air, at the moment of discharge the resistance along the line of discharge is practically nothing, and therefore all the charge is conducted away. According to Faraday, "the ultimate effect is exactly as if a metallic wire had been put into the place of the discharging particles" ("Researches," series xii.). Most of those tried failed.

The survival of the fittest has been exemplified in the "plate" protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line, is placed above it, but separated from it by paper, or by insulating washers. The lightning entering the wire bursts across the paper or air-space in preference to passing through the apparatus, and thus escapes to earth.

An important modification of this plate discharger has been made by Dr. Werner Siemens, who, by serrating, or grooving with a pointed tool the opposing faces of the two plates at right angles to each other, converted them into a conductor which was supposed to be one composed of an infinite number of opposing points. The remarkable action of points in facilitating discharge is well known, and their introduction into lightning protectors occurred very early in the annals of telegraphy by Mr. C. V. Walker, F.R.S.

Messrs. Siemens's arrangement, very pretty in theory, never carried conviction of its value to the mind of the author, because protectors so prepared never singled themselves out as evidently superior to others that were not so prepared, and while the intersection of the grooves certainly formed mathematical points, they did not form physical or mechanical points, and it is upon the action of this latter kind of points that such remarkable electrical effects are produced.

Dr. Warren de la Rue having very kindly placed his well-known battery of 11,000 cells at the disposal of the writer, he prepared four plate-protectors identical in dimensions, excepting that two were serrated, and two were not. The two plates were separated from each other by narrow ebonite washers ·01 inch thick. The upper plate was placed in connection with the positive pole, and the lower plate with the negative pole. The number of cells were increased until a continuous current of electricity flowed.

1.—*Plain Plates*

Number of Cells.		Effects produced.
1,000	...	Slight sparks commencing on completing circuit.
1,080	...	Sparks evident.
1,200	...	Sparks frequent and abundant.
1,500	...	Continuous arc.

2.—*Serrated Plates*

Number of Cells.		Effect produced.
1,000	...	Sparks just commencing on making contact.
1,080	...	Sparks evident.
1,200	...	Sparks frequent.
1,500	...	Continuous arc, but fitful.

2,000 cells in each produced a continuous stream of electricity. The effect with 1,500 cells was decidedly more marked with the plain plates than with those serrated. The experiments were extremely pretty, and very decided in their character. Hence it appears that grooving is not only of no use, but that it rather deteriorates the value of the protector.

These experiments confirm very decidedly the accuracy of the figures obtained by Dr. Warren de la Rue and Mr. Müller on the striking distance between two flat disks given by them in their paper read before the Royal Society (*Phil. Trans.*, vol. 169), where it was shown that 1,200 cells struck across ·012 inch. Here 1,000 struck across ·01 inch, which agrees perfectly with the curve produced by those observers.

It is the practice in the Post Office telegraph department to keep these plates apart by thin paraffined paper ·002 inch thick, so that the air surface is really much thinner than that experimented upon, and the striking difference of potential only 250 volts.

Messrs. De la Rue and Müller have shown that for points and various kinds of surfaces opposed to each other, plane surfaces act the best for potentials less than 1,500 volts, and that points are only efficient for high potentials. Now as it is doubtful whether atmospheric electricity causes much higher potential than 1,000 volts, it is clear than plane surfaces are the most effective for protecting apparatus. It is quite certain that such plates, plain and smooth, separated by an air space ·002 inch thick, will form very efficient lightning protectors.

The author is very much indebted to Dr. Warren De la Rue for the performance of the experiments in his laboratory.

Experiments made to determine the Friction of Water upon Water at Low Velocities, by Rev. S. Haughton, M.D., D.C.L.—The author's intention, in commencing the experiments, was to ascertain the co-efficient of tidal friction, and also to ascertain the elevation of water at the equator or pole, necessary to cause a current; and both these results he hopes to secure with some approach to accuracy.

The experiments were conducted by means of a spherical ball of granite, unpolished, which was suspended by a pianoforte wire, and allowed to hang freely; from the brass collar by which the ball was suspended an index projected on each side, the pointed ends of the indices traversing a graduated horizontal circle, whose centre corresponded with the line of suspension. The suspended ball was immersed in water contained in an iron tube.

On the Tension of Vapours near Curved Surfaces of their Liquids, by G. F. Fitzgerald.—The paper is intended to give a physical explanation of the fact that the tension of a vapour in contact with the surface of its liquid when that surface is convex or concave is greater or less respectively than when flat. It rests upon the assumption that evaporation is not purely superficial but that molecules are emitted from a certain depth beneath the surface of a liquid. From this it follows that the chances of escape of a molecule from a given depth below a convex surface are greater, and from a concave less than from a flat one. Taking the depth from which emission takes place as very small compared with the radii of curvature of the surface, the author has deduced the same formula for the increase or diminution of tension as Sir W. Thomson deduced from capillary phenomena.

Etherspheres as a Vera Causa of Natural Philosophy, by Rev. S. Earnshaw, M.A.—The author, assuming an admitted parallelism between the phenomena of light and heat, proceeds by means of three hitherto overlooked propositions in natural philosophy to establish the universal existence of what he has denominated *etherspheres*, the third of his propositions being—"Every atom of matter in the universe is surrounded by an ethersphere of its own." The following is the system of nature which he finds sufficient for his purpose:—

1. In nature there are two distinct substances, matter and ether, neither of which has any power to attract or repel the other.

2. Matter consists of atoms which attract each other with forces varying according to the Newtonian law $(\text{distance})^{-2}$.

3. The atoms of bodies of the same kind are alike in all respects; atoms of bodies of different kinds differ from each other in size, and possibly also in other respects, such as shape, &c.

4. Atoms, whether of matter or of ether, are incapable of experiencing any change of figure or dimensions; and they are all assumed to be of such geometrical forms as cannot fill space.

5. From the phenomena of light it has been inferred that atoms of ether repel each other with a force varying as $(\text{distance})^{-4}$.

6. Every atom of matter is impervious to ether, and acts on ether in no other way than by pressure of contact.

7. A portion of space filled with matter is necessarily void of ether; and all space void of matter is pervaded by ether.

8. The enormous velocity of light in free space has led to the opinion that very great must be the repulsive power of ether on ether; and it seems to follow from this that an ether atom will experience great difficulty in moving from one part of the ethereal medium to another. Except as waves and currents, ether motion will be under great restraints, and especially shall we see this when we also remember the high power (viz., the fourth) of its inverse law of force.

9. In free space light is believed to be transmitted with the same velocity in every direction, and from this we infer that the atoms of ether are all spherical in form.

The following is the author's definition of an ethersphere:—

All space not filled by matter is pervaded by ether, so that every atom of matter is surrounded by ether, but this is not what is included in the word "ethersphere." The author shows that if any portion of space be rendered void of ether from any cause whatever, that space has become void of the repulsive forces which were centred within it, and that, consequently, when these forces are taken away the medium outside the space will draw closer towards that space; and if the space be occupied by an atom of matter, the density of the surrounding ether will be greater than before, and the ether, being in contact with the atom at its surface, will press upon it. This *excess* of ether about the vacant space above its original quantity constitutes the ethersphere; and though this gathering together of ether about the space now occupied by the atom is a consequence of the presence of the atom, it is in no way owing to its action on the ethereal medium.

The author then argues that if every material atom, so must every compound system of atoms, *i.e.*, every material body, whether gaseous, liquid, or solid, have an ethersphere, which not only surrounds the whole body, but also penetrates the interstitial spaces of the body which lie between its atoms.

By means of these etherspheres the author believes the phenomena of heat may be satisfactorily accounted for, on the supposition that the ethereal medium is the medium of heat as well as of light. They are shown in the original memoir itself to have a remarkable bearing also on the phenomena of magnetism, electricity, galvanism, and the various sciences connected with the agency of imponderables. He therefore concludes that etherspheres constitute a *vera causa* the existence of which in nature is as certain as is that of the ethereal medium itself, about which no philosopher expresses doubt in the present day.

On the Fundamental Principles of the Algebra of Logic, by Alexander Macfarlane, M.A., D.Sc.—In a work recently published, entitled "The Algebra of Logic," the author has investigated anew the foundations of that branch of mathematical analysis which was originated by Boole in his celebrated treatise on "The Laws of Thought." In making this inquiry the author has studied the contributions to the subject made by Harley, Venn, Jevons, and others.

The difficulty and apparent irrationality of Boole's calculus is due to the fact that it is founded on the old and inadequate theory of the operation of the mind in reasoning about quality. That theory supposes that the mind, in forming a compound conception out of two simple conceptions, necessarily considers the second of these as limited by, and in a measure dependent upon, the first; in the theory which the author advances it is maintained that the mind may, on the other hand, form compound conceptions in which the second element is entirely dependent on the first; and, on the other hand, compound conceptions, in which the two elements are mutually independent.

The author considers that the fundamental notion in this branch of analysis is that of a collection of homogeneous objects having differentiating characters. The collection of objects, so far forth as they are homogeneous, may be denoted by u (as they form the universe considered in the particular investigation); a differentiating character may be denoted by a small letter, as x. The symbol x applies to, and is entirely dependent upon, u. The arithmetical value of u is the number of the objects considered, and may be singular, plural, or infinitely great. The arithmetical value of x is the ratio of the number of the objects which have the character x to the whole number of objects considered. The author then explains the meaning of the letters and symbols in this system of logic.

On Synchronism of Mean Temperature and Rainfall in the Climate of London, by H. Courtenay Fox, M.R.C.S.—The object of the paper is by the examination of a long series of facts to ascertain whether there be any law which regulates the *occurrence at the same time* of extremes of temperature and rainfall, so far as we can ascertain it in the English climate.

The facts used are the rainfall and mean temperature as for the Royal Observatory in each month and season for 66·67 years. The mean temperature from 1813 to 1840 is that computed by Mr. James Glaisher, F.R.S., (*vide Philosophical Transactions*, 1850, part 7); and from 1841 to the present time, it is from direct observation. The rainfall from 1830 to 1840 is derived from sundry observations about London collated by Mr. George Dines, and from 1841 to the present time it also is from direct observation at the Greenwich Observatory.

The author has constructed tables *for each month*, in which the sixty-seven (or sixty-six) years are arranged in the order of the mean temperature of that month, beginning with the coldest and ending with the warmest, and also arranged in like manner in the order of their amount of rain. The sixty-seven years are then divided, as nearly as can be, into five equal sections, of which the middle section is termed average years; the division on each side of the average are termed cold and warm, dry and rainy, respectively; while the extreme sections are qualified by the word *very*, being called very cold, very warm, very dry, and very rainy, respectively. We have thus a pretty fair division of the series of years in both these characters. What has been done for each month has been also done on exactly similar principles for each season and for the whole year. The results found were:—

1. In the winter months, cold tends to be synchronous with dryness, warmth with large rainfall.

2. In the summer months, cold tends to be accompanied by much rain, warmth by dryness.

3. Rainy years tend to be either very cold or very warm, whilst years of drought tend to assume an average temperature.

Experiments on the Influence of the Angle of the Lip of Rain Gauges on the Quantity of Water Collected, by Baldwin Latham, C.E., M. Inst. C.E., F.G.S., F.M.S.—The author having observed that, in the ordinary pattern of the Glaisher gauge, in high winds the rain was often driven up the sloping lip and into the gauge, thought that if the rim of the gauge were made very acute, having a sharp knife edge and equal angles both inside and outside the gauge, any rain which might strike upon the outer angle on one side of the gauge might be thrown into the gauge. Rain striking upon the inner and opposite side of the gauge would be thrown out, and so an equilibrium rim would be constructed, as the gain on one side would be balanced by the loss on the other side.

With this view, the author had an 8-inch gauge made and tested alongside of an 8-inch Glaisher gauge. The sloping lip of the Glaisher gauge had an angle of 45° from the perpendicular, and the rim of the equilibrium gauge was ·8 in. deep, ·18 in. in thickness, sloping off on both sides at an angle of 3° from the perpendicular. Both gauges were fixed at Croydon, 4 feet above the ground, and 259 feet above Ordnance datum. These gauges had been working side by side for 551 days, from January 5, 1878, to July 5, 1879, during which period rain or snow has fallen upon 306 occasions. Upon 43 occasions it was found that the rain collected in the Glaisher gauge exceeded, by a small amount, the rain in the equilibrium rim-gauge, and on two occasions the quantity in the new gauge exceeded that in the Glaisher gauge. Upon 261 occasions the rain in both gauges was absolutely equal. On all occasions, it should be observed, the rain from both gauges was invariably measured in the same graduated measuring glass. On the 45 occasions when the Glaisher gauge collected most rain, the wind without exception was high. On the two occasions when the equilibrium rim-gauge collected more rain than the Glaisher gauge, it was probably due to dew, the equilibrium gauge presenting a larger surface for condensation than the other gauge. As the Glaisher gauge was not calculated to contain snow, all falls of snow are recorded in the equilibrium rim-gauge, which is constructed to hold about one foot in depth of snow.

The total quantity of rain collected in the Glaisher gauge during the period of observation, plus the snow as caught in the equilibrium rim-gauge, was 46·68 in., and the quantity collected in the equilibrium rim-gauge was 46·45 in., showing a difference of but half per cent. In all probability, however, the small excess measured by the Glaisher gauge would tend to compensate for the losses by evaporation in periods of small rainfall and at other times, and therefore, as a measuring gauge, the Glaisher pattern of gange, when tested by a gauge of the description mentioned, gives results in practice which may be taken as correct.

Summary of Results

Date.	Total number of days' experiments.	Number of days when rain fell.	Amount of rain collected by Glaisher gauge.	Amount of rain collected by equilibrium rim-gauge.	Times when Glaisher gauge in excess of equilibrium rim-gauge.	Times when equilibrium rim-gauge in excess of Glaisher gauge.
1878.			inches.	inches.		
January ...	31	17	1·145	1·115	6	—
February ...	28	15	1·440	1·430	2	—
March	31	10	1·300	1·295	1	—
April	30	17	3·940	3·940	0	—
May	31	22	3·480	3·460	4	—
June	30	13	3·205	3·190	1	—
July	31	11	·595	·600	0	1
August ...	31	20	5·725	5·690	7	1
September ...	30	11	1·015	1·010	1	—
October ...	31	18	2·140	2·135	1	—
November ...	30	22	3·775	3·735	8	—
December ...	31	20	1·460	1·455	1	—
1879.						
January ...	31	13	2·610	2·610	0	—
February ...	28	22	3·380	3·360	4	—
March	31	13	·540	·540	0	—
April	30	19	2·535	2·515	4	—
May	31	18	3·600	3·595	1	—
June	30	20	3·690	3·680	2	—
July	5	5	1·105	1·095	2	—
Totals ...	551	306	46·680	46·450	45	2

On the Retardation of Phase of Vibrations transmitted by the Telephone, by Prof. S. P. Thompson.—It was predicted from theoretical considerations by Dubois-Reymond that a difference of phase, amounting to a quarter of a complete vibration, would be found to exist between the diaphragms of two associated Bell telephones, the receiving telephone being a quarter of a vibration behind the transmitter. A more complete theory, worked out independently by Helmholtz and Weber, gave a somewhat contradictory result, and required only a small difference of phase. Recently König in a series of delicate experiments, effected an optical comparison by the method of lissajous of the vibrations of a pair of telephones, replacing the vibrating discs by tuning-forks armed with mirrors. The experiment is a delicate one, and is performed under condition not free from objection. The author has proposed the following method of observing. A pair of Bell telephones are suspended by wires of about a metre in length, so as to oscillate as pendulums, to frames so disposed as to avoid the possibility of any mechanical transmission of the vibrations. Below the point of rest of each telephone, and at some little distance from it in the plane of its swinging, is placed a steel magnet. After the lengths of the wires have been so adjusted that the telephones will swing in identical periods, one telephone is set swinging. As it alternately approaches and recedes from the magnet, the induced currents traversing the second telephone set it swinging. In every case the difference of phase observed amounted to one quarter.

In the case of those telephones which transmit vibrations by varying the resistance of the circuit, instead of varying the electromotive force, there is no such retardation of phase produced in the ordinary electromagnetic receiver. If, however, the current so transmitted is first passed through an induction coil, a retardation of phase of one quarter is produced, and in the case of several successive inductions the retardation amounts to an additional quarter for every additional induction. This remark applies only to vibrations of harmonic and quasi-harmonic type. Vowel sounds, which consist of compound harmonic vibrations, are unchanged to the perception of the single ear, which is unable to distinguish differences of phase, or between compound sounds which differ from one another only in the difference of phase of their components. The vibrations of consonantal sounds, on the contrary, depart more and more widely from their original type at each successive induction.

In the case of Edison's motographic or electro-chemical receiver, the velocities, not the displacement of the disc, are proportional to the strength of the currents received. Hence vibrations already retarded one quarter in transmission, as is the case with those of the carbon transmitter in conjunction with its induction coil, always used with this instrument, are restored to their primitive phase. The vibrations of this receiver therefore agree in type, not with the vibrations of the induction current (which correspond to the derived function of those of the original vibration), but with those corresponding to the function of which the vibrations of the induction current are the derivate; that is to say, they agree in type with the primitive vibrations of whatever form. Hence in the receiving telephone of Edison consonantal sounds which depart widely from the purely harmonic type are better rendered than in a telephone which like that of Bell both retards the vibrations in phase and alters them in type.

On some New Instruments recently constructed for the Continuation of Researches on Specific Inductive Capacity, by J. E. H. Gordon, B.A.—Mr. Gordon exhibited and explained the following new instruments which he has arranged during the last year:—

1. A miniature five-plate induction-balance, similar in principle to the large balance exhibited at the Dublin meeting, but intended for the examination of crystals and other precious substances which cannot be obtained in sufficiently large quantities for the large balance.

The large balance requires the dielectric plates to be 7 inches square and $\frac{1}{2}$ to $\frac{3}{4}$ inch thick. For the small balance it is sufficient to make them 2 inches square and $\frac{1}{8}$ inch thick.

2. A gauge for measuring the thickness of the dielectric plates to $\frac{1}{10000}$ inch.

3. A new form of quadrant electrometer for use with the small induction balance.

The capacity of the smaller plates of the little induction balance is so minute that when they are attached to the quadrants of the electrometer of ordinary construction (Elliott pattern) disturbances in them produce hardly any effect on the needle, on account of the much greater capacity of the quadrants of the electrometer.

In order to construct an electrometer whose quadrants should have very small capacity, and which should yet be very sensitive, the author has arranged the quadrants as pieces of a flat disk, only 1 inch in diameter, and the needle has been bent round them so as to be acted on by both their upper and lower surfaces and their outside edge.

4. A new rapid commutator.

This was invented by Prof. Cornu, of the École Polytechnique, Paris, who had the great kindness to devise it for the author of this paper, who, when M. Cornu took up the matter, had just constructed three different instruments for the experiments for which this one is intended, all of which had proved unsuccessful.

Some preliminary experiments with M. Cornu's instrument have shown that it promises to be entirely satisfactory. It can be used with either the large or small induction balance on the one hand, and with a Holtz machine or battery of 500 or more cells on the other. It reverses the electrification of the plates of the balance eighteen times per second, and between each reversal, short circuits, and puts to earth both poles of the induction balance and both poles of the battery. By altering two screws it can be arranged to short circuit and put to earth the poles of the induction balance only, and to insulate the battery poles.

5. Driving-wheel for the Cornu commutator.

All the instruments have been constructed by Mr. Kieser, of the firm of Elliott Brothers.

SECTION C

GEOLOGY

Opening Address by Prof. P. Martin Duncan, F.R.S., Vice-President of the Geological Society, President of the Section

Everyone who is interested in the science which is especially considered in this Section of the British Association for the Advancement of Science must be impressed with the importance of the geological construction of this district in determining its physical geography, in producing the features of its landscapes, and in originating and developing many of the industries of the busy town of Sheffield.

It was inevitable that you should be addressed, at the commencement of your labours, upon the subject of the carboniferous formation, especially as the intention of this peripatetic congress is to advance science amongst those who require it. It will therefore be my privilege to bring before you some of the more important generalisations of the day, and some other considerations regarding the great formation which is so fully developed in this part of England; trusting that whilst many of you will submit to be reminded of the results of the labours of the men who have established our science and of those of yourselves, some who desire further information than they have hitherto obtained may be advanced in knowledge.

Of all geological formations, the carboniferous is the most important to mankind at the present time, and the most interesting to the student. It gives the earliest clear and definite idea of a land surface on the earth, or rather of the existence of many lands; for they are to be traced here and there from high up in Arctic latitudes to Australia, and from the West of America to Eastern Asia. It offers evidence of the existence, even in those remote days as in the much later miocene age, of astronomical conditions which do not now prevail. It yields proofs of the persistence of a vast lowland flora during extraordinary vicissitudes of the relative level of land and sea, and of the existence of a fauna remarkable for its great fish and amphibia, and whose air breathing mollusca and insecta are of surpassing interest, forshadowing as they do many recent forms. And its study indicates that the movements of the crusts of the earth, which occurred during and terminated the age, were of the grandest kind, and have been of the greatest importance to mankind, destroying, it is true, all the vestiges of a large part of a volume of the earth's history, but bringing coal within the reach of the explorer and miner.

This world-wide formation, usually very thick everywhere, has all the evidences of having lasted during a vast age, and there are present in it the relics of sea floors, of shallow seas and estuaries, of land surfaces, rivers, and marshes. The volcanic activity of the age was great, and is capable of demonstration.

So deep are some of the sediments composing the carboniferous formation in different parts of the world, that the idea of exact contemporaneity is not necessarily much modified. It was in all probability "coal time" universally, and for a long duration. But the beginning of the period was not synchronous in different parts of the earth, neither was the ending. The Devonian age lasted longer in some parts of the earth than in others; and the crust movements which so altered the physical geography of the carboniferous hills, dales, and swamps as to develop a new aspect of nature, terminated the period sooner in some quarters of the globe than in others. In such a locality, however as Eastern Hindostan, the duration of a carboniferous type into the secondary ages is apparent. Hence, in spite of a recognised general contemporaneity, it must be credited that carboniferous, Devonian, Permian, and later deposits were accumulated early and late during the lapse of one great age in distant parts of the globe.

The duration of the carboniferous age in the broadest sense, may be attempted, but with no great success, to be estimated by the time which must have elapsed during the world-wide dispersion of identical species; and its biological relation to the preceding and subsequent formations may be appreciated from the fact that the carboniferous flora, lasting as it did from the bottom to the top of the formation, was foreshadowed in the Devonian, and that it founded the mesozoic. Thus the Australian, Himalayan, British and North and South American marine strata of the carboniferous age contain many identical species of Brachiopoda—the variation from the English types, which were the first described, being very slight. Amongst the corals some forms are equally widely diffused. Now, according to what occurs in nature at the present time, the movements of species from one locality to another by ova, or by wafting of the young—the only method of the lateral or horizontal progress of the brachiopoda—for instance, is impeded by many physical conditions, and is constantly rendered abortive by predaceous and obstructive living forms, and by what is called the strugggle for existence. Migration, or rather the extension of the locality of the species, for the first term implies much more than was or is ever done, is so rarely possible to any great extent under the present complicated natural history and physical condition of the earth that the mind fails to grasp the time which would lapse between the commencement of the dispersive process and the establishment of identical species, even a few thousands of miles off. To bring the subject a little nearer, however, it is necessary to consider that the Arctic and Antarctic cold areas and the frigid bathymetrical ocean zones did not then exist, and that the movements of the crust, producing extension of coast lines, were exceedingly frequent during the age, and must have facilitated the dispersion of littoral and moderately deep sea species.

The dispersion of the species of the numerous cryptogamous plants was doubtless rapid in relation to that of the animals, for their spores could be wafted to a great distance by wind, and they do not appear to have had much to struggle against. With the coniferæ it was different, and the examination of the methods in which fir trees spread in favourable localities, at the present time is very suggestive of exceeding slowness of dispersion. Nevertheless, the cones of the coniferæ were carried here and there by water during the carboniferous age.

To add to the notion of the long duration of the age it must be remembered that a succession of identical floras occurred nearly on the same areas, involving repetitions of growth and of migration.

The growing of the vegetation of each swamp and lowland tract, its accumulation and covering up with sand, shales, and gravel, occupied much time, and the last process involved the destruction of considerable breadths of plant life. The formation of under-clay or warp, if the similar occurrences of the present day be taken as examples, occupied much time, and then a lapse occurred whilst the nearest flora supplied a new vegetation to the virgin soil.

In some instances the recurrence of vegetation was evidently the result of spreading from no great distance; but in others so great a depth of sediment separates the consecutive deposits of coal, and the great subsidence which took place is so evident, that the migration must have been from a considerable distance, and must have occupied commensurate time. In endeavouring to appreciate this lapse of time, it must be remembered that, even on the small surface of the United Kingdom, there was land on some parts during the whole of the carboniferous age notwithstanding the diversity of the deposits and the frequent occurrence of marine conditions.

It would appear that prior to those movements of the earth's crust which terminated the physical geography of the Devonian age, three elevated tracts of land crossed the kingdom from west to east, and that there were mountainous regions running northwards and north-westwards, including North Wales, Western Ireland, and much of the North Atlantic.

The southern high land barrier passed somewhere in the direction of the Bristol Channel, and then to the east and slightly to the south, having a somewhat definite continuation with the Ardennes. The central barrier, or high land, passed from Shropshire eastwards by Leicester, and then to the coast; and the northern was formed by hills in the present lake district, extending eastwards. On the south of the southern high land, the marine Devonian accumulated in a coral sea, and to the north of it and between it and the central barrier the old red lakes obtained their water supply and sediment from the Welsh hills of the period. North of the central barrier, interrupted lakes and land occurred, and also to the north of the northern barrier. The dry land and the barriers and hills were formed by sub-rocks of Silurian and Cambrian age.

There is no evidence to indicate that the southern barrier was of great height at the end of the Devonian period, but there is some which points out that the first physical change which initiated a new aspect of nature—the carboniferous—was a general subsidence of the region. The coral reefs sank below the bathymetrical zone of the composite forms, and the sea breached the barrier. The southern old red lake began to have its waters impregnated with salt, and its great ganoid fish were replaced by the cestraciont sharks of the age. These left their remains in the bone bed at the base of the lower limestone shales, which are the earliest of the carboniferous series there. The irruption of the sea appears to have taken place to the north of the central barrier also, and the subsidence was great there, a limestone with some sandy strata forming gradually. In the north and north-east, in the present district of the Tweed, deposits collected in shallow water, and vegetation grew which formed the coals at the base of the great Scour limestone.

On the same and on slightly higher horizons are the coals of Fallowfield, Tindal Fell, and Heskett. These are the earliest evidences of the carboniferous vegetation, and it was doubtless in full vigour whilst marine conditions existed to the south.

Probably the high lands constituting the barriers were not covered during the subsidence, which permitted the accumulation of the marine deposits of the carboniferous limestone age. For close to the coal-fields near the central barrier, and which rest on upper Silurian rock, borings here found the remains of carboniferous plants on the palæozoic rock without the intervention of any sediments.

Now the depth of the deposit of limestone about this central barrier is great, and the question arises how was it produced in the immediate proximity of land which was not covered by sea, and which does not appear to have sunk contemporaneously with the sea floor close by? Sinking along definite lines bounded by faults is the only means by which this can be explained; and this suggestion, which was a favourite topic with Phillips, is all the more probable, when it is remembered that the area of accumulation to the north of the barrier was one of vast subsidence during the consecutive ages of the grits and coal measures, whilst there was land still further north. If the stability of one and the instability of the other are not conceded, the original height of the barriers must have been stupendous and beyond example, so far as the size of their bases is concerned.

There are many examples of what I resolved to call in a presidential address before the Geological Society areas of comparative instability and which relate apparently to radial upheaval subsidence along long lines of country where movement has been rare. An instance on the grandest scale is seen in the history of the Himalayas in relation to the peninsula to their south and south-west. For whilst this last area was land during a vast age, that of the Himalayas was repeatedly a marine tract, and suffered subsidences and elevations.

Still further north and beyond the northern barrier, in the Scottish area, carboniferous plants lived a little later, and after a subsidence which permitted the lower calciferous series to accumulate. The lowest coals of the basin of the Clyde are of this age, and the accompanying clay, ironstone, and the fresh water limestones and gigantic fish of Burdie House are all indications of terrestrial conditions. All these evidences of carboniferous vegetation occur in the geological horizon of the carboniferous limestone and Yoredale series.

Never entirely free from sandy impurities the carboniferous limestones north of the central barrier gradually became covered with a thick arenaceous series containing here and there marine fossils and traces of coal plants. These are the Yoredale strata, which consist mainly of the sediments of a somewhat distant north-westerly land, the plants of which were carried to sea by rivers and deposited here and there on the sea floor. It would appear from the evidence collected by the Geological Survey that, after a very considerable thickness of these rocks had collected, either a filling up of the shallow sea or a slight upheaval of the floor occurred, for denudation of their surface happened, considerable depressions and ridges being produced on it. On those spaces and ridges, and indeed on the whole surface of the Yoredale rocks, collected strata which are popularly called the millstone grits, so well seen west of Sheffield. All the depths of this great land wreckage, consisting of silicious and felspathic sandstones and shales, accumulated on a sinking area, some near land and the rest in deeper places. And here and there coal seams are found intercalated, being evidences of the existence of contemporaneous vegetation. Some of them are workable, and others are only valuable as evidences of the existence of the vegetation of the age; many are placed on a hard silicious or ganister bed, but some have an underlying fire-clay. They are very usually covered with deposits containing goniatites and aviculopecten, which doubtless are the remains of marine organisms.

Admitting, therefore, that some of this millstone grit coal may be the result of the drifting and sinking of the vegetation from off lands rather remotely situated, it is still evident, from the existence of the under-clays elsewhere, that some of the grits, by silting up, or by slight upheaval, above sea level, formed the subsoil of swampy ground on which vegetation grew. This approach of the millstone grit sea floor to above sea level was decided enough in the region of the great coal-field around us, for a conglomeratic rock—the rough rock—occupies a somewhat definite horizon on the top of the series.

This rough rock collected in shallow water, and it is important to the geological surveyor, for it formed the base on which the coal measures, proper, rest; and it is suggestive to the physical geologist that a general and wide, but not great, upheaval took place which removed the ocean of the day further off, and which determined a total change in the direction of sediment-depositing currents.

Hitherto the greatest thickness of the sediments of the millstone grit age had been towards the north-west, and the direction of the currents had been from north-west to south-east, but subsequently, as has been suggested from very strong evidence by Sorby, the depositing currents of the next age had no very definite direction. But the carboniferous land of this part of Europe was not yet remote from the sea. Much of it was on the borders of estuaries, and the aspect of nature was probably that of wide flats of grit covered usually by terrestrial vegetation and occasionally overwhelmed by sea. In fact, both practically and theoretically there is much difficulty in separating the mill-grits from the lower coal measures. The lower measures contain some thick and widely-spread sandstones, and the important coal seams, in some instances, rest on a hard ganister bed, and in others on a fire-clay. And to add to the similarity of the deposits of the upper grits and lower coal measures, marine fossils, such as species of goniatites, aviculopecten, and posidonomya, are intercalated above the coals. But the evidences of marine invasion ceased as the deposits accumulated, and more perfect terrestrial conditions arose. The Elland flag-stones, for instance, such prominent features to the west of this town and in the neighbourhood of Halifax, are fresh-water deposits, and are undoubtedly accumulated in an under-clay indicative of terrestrial conditions.

In the region north of the northern barrier successive coal seams and impure limestones and fire-clays occurred during the age of the depositions of the English grits, and then a thick fossiliferous sandstone was followed by the upper coals of Mid-Lothian.

All the minor upheavals and upsiltings of this long age were subordinate to a progressive general subsidence, in which the central and northern barriers were slightly implicated, and this extraordinary crust movement was to continue during the accumulation of over 3,000 feet of coal measures and other deposits, all subaërial in their method of formation, or having collected in shallow water or swampy ground. These products of denudation and of organism succeeded each other time after time; great gravels, shales, and sands were intercalated, and even traces of some of the rivers of the age are to be found breaching the seams. The more the subject, commonplace as it may be thought, is considered, the more astonishing does it become, for the regularity of the subsidence and its amount must have kept pace with the thickness of the accumulating deposits. That there were many long intervals of quietude in the earth's crust may be gleaned, not only from the thickness of many coal seams, but also from the subaërial denudation which occurred. For instance, high up in the series in this district, is a mass of red sandstone which covers the denuded middle measures beneath; and this red rock of Rotherham, the result of coal measure denudation and removal, accumulated during the early days of the upper coal measures, for it is lower in the geological series than some members of the uppermost coal measures.

Before the close of the age, marine conditions occurred in the rock, and a limestone with goniatites was formed; but still coal seam formation proceeded until a totally different series of crust movements commenced in this country.

The flexures which were produced at the close of the carboniferous age had their long axes east and west; they suffered denudation and on the worn edges of their strata the "used-up carboniferous"—the lower Permian. Elsewhere, resting apparently and often really conformably on the carboniferous strata, the Permians accumulated until great north and south curvatures occurred and produced the Pennine chain.

The denudation of the anticlinal or upward curves of the north and south flexures progressed, and the coal measures, once continuous across England, were worn off along the back-bone of the country and from off the east and west ridges also. Vast as was the destruction and removal, there was still more compensation in nature, for faulting occurred on a large scale, and the measures were in many places sunken down below the level of possible subaërial denudation. It is to the pre- and post-Permian crust movements in producing basins and in uptilting the formerly horizontal seams, and to the subsequent faulting, that we owe the preservation and the possibility of reaching and working much of the coal of this country.

It appears that the position of this town refers quite as much to some remarkable faults, and the results of the post Permian uptilting, as to the presence of the river Don. Two important lines of fault run almost parallel, the one traversing the centre of Sheffield, and the other being to the north of the outcrop of the Silkstone coal. They pass in a north-easterly direction, and the country between them is much broken. Moreover, by a combination of the results of uptilt and faulting, the strike of important coal seams has been so altered that they encircle the town on the south, west, and north. The mineral products have thus been brought within the reach of those by whose industry this town has increased in size and population.

With regard to the lithology of some of the great series just mentioned, it may be suggested that the condition under which the beautiful limestones of the Avon, and the dark, shaly, muddy, calcareous deposits of the corresponding age accumulated in Scotland, were very different. The stone in the southern example is many-coloured and is nearly an organic deposit, whilst the shaly strata of the northern series have crowds of calcareous fossils in them. Remove the shaly substance, however, and consider and compare the fossils of both localities, and no satisfactory distinction can be drawn between the depths at which they may have accumulated.

Both deposits contain crinoids, polyzoa, brachiopoda, and simple and compound hydro-corals. The same occur in the limestones to the north of the central barrier, which are intermediate in the arenaceous condition between those just mentioned. It is admitted that the mineral condition of the original deposits has altered, and it is possible that much impurity may have been removed by percolating carbonated waters, from the purest of the limestones. And, indeed, unless this is credited, it is impossible to compare some of these old marine sediments with any now forming on the floor of the sea. All the known calcareous sea floor deposits contain a very considerable percentage of silica and other matters, and if the carboniferous limestones were ever in the condition of modern deep-sea ooze, in order that they should have looked like the chalk they must have lost in some manner or other more than 35 per cent. of impurities. So far as I can understand, much of the carboniferous limestone may have accumulated at no very great depth and on banks within the scour of currents, and their prevalence would account far the comparative absence of sandy sediments in some situations. No traces of atoll formation exist.

With regard to one or two late discoveries relating to the organic remains of the carboniferous limestones, it is necessary to refer you to Moseley's important work amongst the Tabulata. These must now be removed from the true stony corals, and some will be relegated to the Hydrozoa, and others to the Alcyonaria. It is a fact of great interest that Sorby should have noticed that whilst the modern true corals are built up of carbonate of lime in the form of arragonite, the great tabulated forms of old are composed of calcite.

Quite lately Mr. Busk has been investigating the large polyzoa of the genus Heteropora, and I saw, under his manipulation, that this recent and Crag group, with strong palæozoic affinities, is so constructed that the branching tubular organisms of the oldest rocks with perforations in their walls and tabulæ must be included amongst species of genera closely allied to it.

A host of ill-defined tubular forms, such as the Stenoporæ, will thus find a final zoological resting-place.

The arenaceous series of the carboniferous formation in England are not less wonderful than the calcareous. They thin out very rapidly from 10,000 feet in the Burnley district to 100 close to the central barrier in Leicestershire, and it would appear that the sea drift was from the present region of the North Atlantic, along the shores of the swampy coal plant-growing-land.

The arenaceous deposits to the south of the central barrier have the same general relation as those to the north, and the grits of the Welsh and Bristol coal-fields are silicious, and were in all probability derived from the Silurian and old red rocks to their north-west. The culm measures of Somersetshire and Devonshire—those thick deposits with impure thin coals with limestones towards the bases—are of the age of the upper parts of the carboniferous limestones and of the grits of the central area. The evidences in this age of the denudation of granite and other silicious lands, and of more or less distant diffusion of the sediment, extend far and wide from the United Kingdom, a belt of similar rocks being found in south-western and central Europe. It is, moreover, very probable that the upper Vindhyan rocks of Hindostan, those fine sandstones and grits which have yielded the building-stones to the great Gangetic cities, are of the same relative age (or slightly older) as the strata of which so many Yorkshire towns are mainly built.

Whence came the thousands of feet of the sands and shales of the coal measures? is as yet a question which cannot be answered. It appears that very widely distributed deposits of the same kind are comparatively rare amongst them, and that most of the organic deposits, as well as the inorganic sedimentary, do not extend over great breadths, but are more or less lenticular in shape, or thin out or become changed in their lithology. This fact and Sorby's suggestion that the currents which deposited the strata had not any definite course rather tend to the belief in the former presence of a vast delta during that ancient aspect of nature. It is certain that some of the vegetation which subsequently became coal, and many feet of the roof above, were not always formed with great slowness, for stumps and trunks of trees have been found standing where they grew, with their roots in their under-clay and their stems wrapped round with coal, and the shale and gravel above. Moreover, in some places, a series of these interesting relics exists, one set being placed above the others.

With regard to the coal itself, varying as it does in its physical peculiarities, all that has an under-clay grew as vegetation on land. It is at present rather difficult to believe that where a coal-seam is found upon a hard silicious bed without a vestige of clay or of old soil, its plants were rooted there. But the stigmarian roots are not unfrequent in the ganister, and at the present time a peculiar vegetation is growing on the grits to the west of this town with a very small amount of humus intervening. Some coal-seams, especially the cannels, would appear, however, not to have been produced by plants which grew on the rocks beneath, and they are the result of vegetation drifting and becoming water-logged.

In reflecting upon the history of those carboniferous deposits in relation to the subsequent great changes in the physical geography of the earth, the idea that geological histories repeat themselves does not obtain that importance with which it is credited in relation to human events. It is true that there were important triassic, oolitic, wealden, neocomian, and tertiary lands, whose vegetation has been metamorphosed into a kind of coal. But the wonderful depth and the extraordinary vertical repetition of organic and inorganic deposits, of the carboniferous formation, and the remarkable crust movements which enabled them to accumulate, are without subsequent examples.

In conclusion, I must remind you that the volumes of the "Geological Record" give the literature of the carboniferous formation year by year, and that lately a magnificent contribution to the subject has appeared in the memoirs of the Geological Survey of England and Wales in the form of a great volume on the geology of the Yorkshire coal fields, by Prof. Green, one of our vice-presidents, and Mr. Russell. A very concise and excellent geology of the West Riding has also recently been published by Mr. Davis, who is amongst us to-day, and Mr. Bauermann has contributed a capital article on coal to the "Encyclopædia Britannica."

THE FRENCH ASSOCIATION

Montpellier, Sunday

THE French Association for the Advancement of Science met at Montpellier on August 28. The president this year is M. Bardoux, the late Minister for Public Instruction, who has been succeeded by M. Ferry.

His address was devoted entirely to generalities on the necessity of providing a good education for the young. He did not touch upon the great question which agitates the public mind in France in connection with the Ferry Bill. It may be inferred from the strong encomiums passed on M. Jules Simon, that M. Bardoux must be ranked among the opponents to the Ferry Bill.

M. Laissac, mayor of Montpellier, and M. Cazelle, prefect of the Herault, replied to M. Bardoux. M. Saporta, the general secretary, gave an address summarising the results of the last year's meeting, and M. Georges Masson read a financial statement which showed that the capital of the Society amounts to about 300,000 francs. The subsidies paid for research last year amounted to 10,000 francs.

These addresses being the only ones which were given in the name of the Association, and as the presidents of sections gave no official addresses, it will be quite impossible to have any idea of the opinions of the meeting on the topics of the day.

Although but a small city, Montpellier is famous in the annals of science, and in former years its university was deemed a rival to Paris. But in latter years Montpellier has lost much of its *prestige*, although it had the honour to be the birthplace of Auguste Comte. The growing academy of Toulouse disputes with Montpellier the pre-eminence in south-eastern France. Meanwhile the impending meeting of *savants* at Perpignan on the occasion of the inauguration of Arago's statue at the end of September will throw the Montpellier meeting somewhat into the shade, and deprive it of a number of constant and influential members. The interest of the meeting will consist principally in excursions professing to promote ends of great moment for the welfare of the region, viz., the extinction of phylloxera, the construction of an irrigation canal from the Rhone, the local meteorology and botany, which are strongly represented by M. Charles Martius, a brilliant writer, and the director of the celebrated Montpellier plant-gardens. A specimen of the French Atlantic cable now in course of being placed, will be exhibited and explained by M. Gariel, the general secretary of the Council, and the scheme of the French Company explained for the first time. Experiments will be made on electric lighting and the telephone.

The French scientific caravan, officered by MM. Quatrefages, Mortillet, and Broca, to be sent to the Congress of Anthropology at Moscow, is to arrive in Montpellier before the end of the meeting. M. Bergeron, one of the French *savants*, who was present at the Sheffield meeting, has arrived in order to tell the French Association of what was done by her elder sister.

THE SWISS NATURALISTS

THE sixty-second annual meeting of the Swiss naturalists was opened on July 10 at St. Gall. The attendance was comparatively large, no less than two hundred Swiss and twenty-one foreign *savants* being present. Among the latter we notice Prof. Hébert (Paris), Mr. Forrer (San Francisco), Herr Nördlinger (Stuttgart), Dr. Richthofen, and many others.

On Monday, the 11th, the first public meeting was opened at the Grossrathhaus, before a large audience of visitors and ladies, by Dr. Rechsteiner (St. Gall), who gave an address on the recent progress of science; also pointing out the importance of the neighbourhood of St. Gall for the study of geology, and discussing the variety and importance of chemical processes in the life of nature. A second lecture was given by Prof. C. Vogt (Geneva) on the archæopteryx, the interesting reptile-bird which has provoked so animated a discussion among anatomists, and of which we possess only two specimens—that of the British Museum and that newly discovered at Solenhofen, Germany. According to the first, which was very incomplete, this Jurassic animal was considered as a bird, having a beak, nails, and feathers; while the Solenhofen specimen, quite complete, and of which Prof. Vogt exhibited very good photographs, proves undoubtedly that we have to do with a bird-like reptile of the size of a pigeon, which had both scales and feathers, a beak provided with teeth, armed wings, bird-like feet with nails, and a reptile tail consisting of twenty vertebræ. This discovery gave to Prof. Vogt the occasion to make a brilliant address on the origin of species, the adaptation of organisms to the medium they inhabit, and the way in which this adaptation goes on from the periphery to the centre.

Two other lectures were given by M. Victor Fatio, on the phylloxera, and by M. Raoul Pictet on the synthetical theory of calorific phenomena. The naturalists then went to the traditional breakfast served on paper table-cloths with paper napkins, in the beautiful hall of the Kornhalle, the walls of which are decorated with four pictures, by M. Kirchofer, which represent the country of St. Gall during the periods of the lignite (*Schieferkohle*), of the molasse, of the glacial epoch, and of prehistoric man. At two began the sittings of the sections. In the Section of Physics Prof. Hagenbach opened a very interesting philosophical discussion on "centrifugal force," in which discussion he was followed by Prof. Mousson (Zurich), who made a valuable communication on the structure of solid bodies, and on the molecular phenomena which produce the phenomenon of heat. Prof. Pictet (Geneva) explained his researches into the mechanical theory of heat. On the following day Professors Forel (Morges) and L. Soret (Geneva), the indefatigable students of the oscillations of the level of the Lake of Geneva, gave, in the Section of Physics, very interesting communications on that subject, and especially on the rhythmical oscillations described as *seiches*.—M. Dufour having communicated the results of his measurements on the glacier of the Rhone, according to which the lower extremity of this glacier has receded no less than eighty metres (260 feet) during the last two years, a long discussion on the causes of the oscillations of glaciers was engaged between MM. Dufour, Forel, Mousson, and Hagenbach. Finally we notice in the Section of Physics the communications, by M. H. Dufour, on the diffusion of gases; by Prof. Hagenbach on the forms of hail; and by Prof. Colladon (Geneva) on his theories on the optical properties of ice.

The sixty-third meeting will take place next year at Brieg, in the Valley of the Rhone.

SCIENTIFIC SERIALS

The Journal of Physiology (vol. ii. No. 2, issued July).—On the effect of the respiratory movements on the pulmonary circulation, by H. P. Bowditch and G. M. Garland.—On absorption without circulation, by B. F. Lautenbach.—On protagon, by Arthur Gamgee and Ernst Blankenhorn.—On a few further experiments with pituria, by Sydney Ringer and William Murrell.—On the antagonism between pilocarpine and extract of *Amanita muscaria*, by Sydney Ringer and William Murrell.—On some old and new experiments on the fibrin-ferment, by Arthur Gamgee.—On the effect of two succeeding stimuli upon muscular contraction, by Henry Sewall.—There is added a list of titles of books and papers of physiological interest published since December 31, 1878, to date.

Journal of the Royal Microscopical Society (August).—Transactions.—On a new species of excavating sponge (*Alectona millari*), and on a new species of Raphidotheca (*R. affinis*), by H. J. Carter, F.R.S.—On a new genus and species of foraminifera (*Aphrosina informis*), and on the spicules of an unknown sponge, by H. J. Carter, F.R.S.—On the theory of illuminating apparatus employed with the microscope, by Dr. H. E. Fripp.—Observations on *Notommata Werneckii* and its parasitism in the tubes of Vaucheria, by Prof. Balbiani; translated from the *Annales des Sciences Naturelles* (*Zoologie*), 1878.—The record of current researches relating to invertebrata, cryptogamia, microscopy, &c.