THURSDAY, MAY 9, 1878

PHYSICAL SCIENCE FOR ARTISTS

I.

We have it on the high authority of Lord Beaconsfield that the English School of Artists is arriving at a pitch of unexampled excellence, and that English art is in the future to be the cynosure of an admiring world.

It is Lord Beaconsfield's opinion that the time has arrived in which we may speak of a school which has flourished for a century with some accuracy of deduction as to its principal features. The principal features of the English school are, he thinks, now recognised. "All will admit that it is a school of great originality. All will admit that, in some provinces of painting, it has certainly established a reputation which may be rivalled by some nations, but which can be surpassed by none. Its power of portraiture is recognised in the most classic galleries. As far as landscape painting is concerned, it has achieved the highest aim of both branches of the art—whether ideal, like the enchanted castle of Claude Lorraine and the classic groves and solemn temples of Poussin, or whether it has competed with the freshness of Hobbema or Ruysdael, English art can match the *chefs d'œuvre* of every country."

This is high praise, and we may gather from it that so far as the reproduction of form and colour goes our artists have arrived at the highest knowledge and skill. Of late years also, we are told, the English school has given an indication of aiming at a higher range of imaginative composition than has hitherto prevailed; and this Lord Beaconsfield holds is natural, because if there is an imaginative nation in the world it is the English nation. "It is the nation that has produced the greatest number of poets—the greatest number of illustrious poets—and, therefore, the British artist has a heritage of imagination which ought to be to him a fund of inspiration." Nor is this all. "He has also another advantage which no great school has yet possessed—he has a larger range of subjects. What the pictures of antiquity were we know very little. We know very well that Zeuxis painted a curtain that deceived his patron, but if that were a test of his school it might, I believe, be stood by the commonest scene-painter of the nearest theatre. With regard to the Italian masters, we know their admirable works abound; they established, not one school, like England, but many schools. Those schools produced many pupils, and their prolific works charmed and instructed the world. But if you look to the great creations of the Italian schools, you will find, generally speaking, as far as subjects are concerned, their range was extremely limited. They drew their inspiration from two religions—the Christian and the Pagan; and every one must feel, when he examines a gallery of Italian art how much it is to be regretted that such genius and power should not have commemorated the great acts of their own history. . . ."

Under these circumstances Lord Beaconsfield takes a very favourable view of the English school. He believes that "there is a feeling which will not be satisfied in the works of art if art does not aim at the production of the highest modern style of imaginative creation." That our artists will shine here the noble speaker is convinced. "I rely on the fact that there never has been a limit to the increasing excellence of English achievement when a fair and just opportunity was offered to it; and, therefore, I do look forward to a period of which, I think, we have many symptoms and encouraging circumstances about us, when imaginative art will be characteristic of the English school, as well as that sense of humour and that *exquisite feeling of nature* and intellectual delineation of portraiture to which I have before referred."

The result predicted by Lord Beaconsfield is of course a consummation devoutly to be wished, and if it be true that Art is Nature passed through the alembic of Man, then this highest style of imaginative creation should largely increase the number of students of science in this country, because, although Lord Beaconsfield was careful not to say too much about Nature, she is there all the same, and the laws which underlie the phenomena which it is the function of art to embody should, at any rate, possess some interest to the artist, and if he is to surpass Nature, he must not hope to do this by evading her.

In art as in science, imagination must have a basis to work upon, and the surer the basis the more will the imaginative effort which transcends it be in sympathy with those hidden powers of the mind and those hidden feelings which it is the function of art to bring into play.

What little I know of the history and development of art would seem to show that in the early days at all events the artist was second to none in his appreciation of the science of the time. Geometry was rapidly applied to perspective, anatomy to form, and although the dwellers in Italy had the finest examples of ancient art to appeal to, it is not difficult to trace the rise of such men as Leonardo da Vinci and Michael Angelo to the direct influence of the study of anatomy first introduced at the University of Bologna. Da Vinci was, as is well known, almost as famous for his knowledge of science as for his productions in art. Indeed the anatomical studies carried on in the wonderful medical schools of Italy during the Middle Ages may be said to have left a greater mark on the world from an art point of view than they have done in the domain of the science of surgery.

Galileo, when he took so large a share in founding the physical science of to-day, was a student of medicine; the wonderfully regular swing of that famous lamp at Pisa suggested to him in the first instance a method of observing the flow of blood through the veins. The idea that here was a perfect method of dividing the flow of time—the idea of the pendulum clock—did not come till afterwards. Still the teaching of the medical school was no more to Galileo than it had previously been to Leonardo da Vinci or to Michael Angelo.

Now what is the condition of things to-day? We might be in the same position with regard to physical science—the science of colour—as Da Vinci and his contemporaries in the 15th century were with regard to biological science—the science of form. The whole range of physical science—a branch of knowledge which has existed for two-and-a-half centuries, but which has lately been developed enormously precisely in those directions of the greatest value to the artist, has not yet been annexed by the students of art.

So far as I can see there is not among artists generally—among those even who acknowledge their obligations to mathematical and biological science in the regions to which I have referred—the notion that they have anything to learn from physical science—physical science being reduced, at all events it will be convenient that in what I now say I shall take it as reduced, in the main, to optics. There seems to be a sort of notion that there are no laws underlying the phenomena of air, and sky, and sea; that while the shape of a horse's leg is defined by law, the order of colours, for instance, in a rainbow, depends upon the play of blind chance. Indeed I have been informed—and I may tell the story here because it hammers my point home better than anything I could say—that an eminent artist, now living, who had painted a rainbow practically inside out, when the picture was returned to him in order that the colours might be corrected, was so indignant with this attempt to interfere with this special development of the "highest style of imaginative creation," to use Lord Beaconsfield's words, that he charged the trifle of 20*l.* for attempting to place the colours in the order in which monotonous nature perversely insists they shall stand.

This is a general attitude, not only of artists, but of would-be teachers of art, and these latter piteously make tempting officers of the whole range of theology for science to work her wicked will upon, if only art may be spared from her contaminating touch. This is not, however, the universal attitude, as I can abundantly testify. Some of our modern painters do most enthusiastically enter into the study of physical science not only for its own sake, but in order to embrace it in their art. It has been my great privilege during the last few years to discuss with painters of the highest eminence questions bearing on art which have arisen from my own investigations in another region of work, and in the study of which the works and observational powers of the artist have been of the greatest value to me.

It is as a result of these many conversations that I have determined to put on paper a sketch of some of the many points in which I think the interest of the operation of nature's laws is as great from an artistic as from a scientific point of view. I shall, I hope, be able to throw these notes into order, but I shall content myself at first with giving an idea of the result of such studies upon art criticism. Whole reaches of art will remain untouched by physics, and its influence will be chiefly felt by the landscape-painter. It is only those who are ignorant of the development of art who will look with suspicion upon the new tests of truth with which artists can supply themselves—with the new ways of tracing effects to causes. Art criticism must gain considerably, for in place of jargon we may in time find common sense, and when once this basis is secured then the more secure will be the "highest style of imaginative creation" resting upon it.

I shall best indicate what I believe will be the influence of the study of optics in the future on art, by stating, by way of introduction, in its most naked form the result of an appeal to the newest branch of knowledge as a test of the truth to nature of several of the pictures in this year's Academy.

The recent results obtained by the workers in spectrum analysis have added so much to our former knowledge of the actions which go on when light is given out, or reflected, or absorbed, that almost all the optics the painter really requires conveniently lies round the most recent work in molecular physics, for the reason that it is the action of molecules which builds up the world with which the artist has to deal.

The instance I shall take in this paper is the following one. One of the smallest of the developments of the new branch of optics supplies us with facts which can be embodied in a simple working hypothesis. The approximate truth of this can be brought to the test by the various colours of the sky. When I say "working hypothesis," I use a term well known to men of science to indicate a train of thought to work upon and test. It is a first approximation to a general grouping of many facts, and it is perhaps as much generated by imagination as by work. It is not a hypothesis in the ordinary sense of the word, because it has not borne sufficient tests, and it especially is not a thing to be dogmatic about (and by this I do not mean to imply that there is anything whatever which ever should be) but still I think it will serve my turn.

Although I have never painted a picture, and am no art critic, yet I have criticised the pictures in this and former years with the most intense pleasure from the scientific point of view. This year I have limited myself to sky colour, and I have prepared two lists, one, including those pictures which I think in harmony with nature, and the other those which represent phenomena which, however probable in any other planet, are, I think, physically impossible in this.

I have done more. I have tested the hypothesis by the pictures. I have gone over those in which I was chiefly interested from my narrow point of view with two artist friends of great distinction, and I have asked them whether the view at which I have arrived in each case was correct. The test I had applied had failed me in no instance.

Here then are the most salient examples included in my lists. I dealt with pictures, not artists, and carefully avoided seeking the artist's name in any case; but here I must bring them out, in order to refer to the pictures with sufficient completeness.

First, then, to deal with those pictures in which cloud and sky colour are, I think, correct:—

3. "The Timber Waggon"—C. E. Johnson. Accurate study of the absorption of light by a slightly hazy atmosphere.

63. "A Summer Flood"—H. R. Robertson. Colour of cumulus clouds glowing with the reflected light of sunset, perfect.

105. "The Cornish Lions"—John Brett. Remarkable picture: the colours and the atmospheric absorption, and therefore transformation of the colour, perfect.

153. "Evening"—R. C. Leslie. Wonderfully true rendering of a very rare effect.

230. "Estes Park, Colorado, U.S."—Albert Bierstadt. Very fine atmospheric study. The vapour rolling down the valley leaves its effect on the picture marvellously.

267. "Wandering Shadows"—P. Graham, A. Magnificent picture. Notice the effect of the atmo-

sphere laden with aqueous vapour on the colour of the hill in the background.

268. "The Alps at Rosenlaui"—V. Cole, A. Gloriously true. The fading of colour in the distant bosses is perfectly rendered—the depth of the atmosphere can be gauged.

306. "Struyve Rocks, coast of Arran"—Geo. E. Hering. A red sunset, nearly perfect in colour from top to bottom; if the yellow had faded into green it would have been better. Compare red with 353.

324. "Conway Marsh"—Jos. Knight. Sunset green, and deep blue hill admirable, but I doubt the colour of the foreground.

405. "Gleaners"—H. R. Robertson. Red, yellow, green, good. Moon nearly right, which is wonderful. (This by the way).

587. "Shining after Rain: Loch Etive"—Geo. E. Hering. The work of a careful observer.

615. "The Lowing Herd winds slowly o'er the Lea"—H. W. B. Davis, R.A. Perfect sunset (poor moon!). (Again by the way).

647. "An Autumn Walk"—A. E. Emslie. Good red and yellow.

739. "Sunset on the Jungfrau, Mönch, and Eiger"—Jas. W. Smith. The blue below and red above on the snow perfectly rendered.

788. "The Written Valley, Wilderness of Sinai"—Henry A. Harper. Good, but not so good as 739.

I next come to those pictures which I think are inaccurate in colour.

86. "Christiana with her Family, accompanied by Mercy, arrive at the Slough of Despond: Mercy finds a way across"—R. Thorburn, A. Impossible cloud colours. Clouds bluer than sky and atmosphere nowhere.

146. "Solitude"—P. F. Poole, R.A. Impossible green sky and cloud.

201. B. Riviere, A. Unnatural moonlight and impossible pea-soup shadows. The softness and colour of the latter suggest that Mr. Riviere has never studied moonlight.

231. "David, the Future King of Israel, while a Shepherd at Bethlehem"—J. R. Herbert, R.A. Colour impossible both in quantity and quality.

240. "A Dream of Ancient Egypt: the Morning of the Exodus"—Andrew MacCallum. I should like to hear the painter lecture on the connection of the colours of bodies with the light which falls upon them.

298. "Jarl Hacon in the Pentland Firth"—J. Hope M'Lachlan. High blotches of red over green and yellow impossible, and brick-dust beams of light proceeding from nothing still more impossible.

309. "The Sunrise Gun, Castle Cornet, Guernsey"—Tristram Ellis. Sky colour good; impossible colour of water under sky conditions given.

353. "After the Rain"—W. H. W. Foster. Unnatural sunset, colour and distribution of light wrong.

424. "The Last Journey"—Clara Montalba. Impossible green sky; the sun is neither setting nor set.

483. "An Autumn Sunrise"—Cecil G. Lawson. Interesting as a foretaste of the future when the sun shall have cooled.

525. A. Dixon. Green hopelessly wrong.

542. "The Dee Sands"—J. W. Oakes, A. Sky colours impossible with so high a sun.

555. "The Last of the Wreck"—E. Ellis. Green clouds!

630. "An Incident by the Wayside"—Mark Anthony. Impossible blue sky.

These, then, are the pictures I shall use as texts in my future notes. J. NORMAN LOCKYER

THE AMERICAN STORM WARNINGS[1]

I HAVE now to direct attention to "Atlantic Storms,—Whence they come and where they go?" All storms that cross the Atlantic Ocean to the coasts of Europe come from the equatorial zone of the Atlantic from the Pacific Ocean, or are developed from depressions on the American continent by peculiar operations of the law of atmospheric movements. The most prolific source of storms for the field of observation just sketched is the Pacific, but all the disturbances coming thence do not necessarily originate there. As I have stated, storms pass over the Pacific from the Asiatic as they do from the American continent over the Atlantic, but generally in more northerly latitudes. Their number cannot be accurately determined until a similar system of observation to that now in operation from the West Indies to Newfoundland is organised on the Eastern coast of Asia. As it is we are dependent on observations made along the Pacific coasts of the United States, British territory, Mexico, and the Central American States, for information regarding the arrival of storms from the westward on this continent. Fortunately the observers are now numerous enough to constitute an effective guard against the possibility of even a small storm centre passing inland unnoticed. These coast observations furnish reliable evidence of the fact that storms arrive on this continent from the Pacific much in the same manner as Atlantic storms reach Europe. It is my purpose to trace as closely as possible the movements of the various types of storms that originate in or cross the Atlantic from west to east, and I will begin with those whose first appearance is observed on the Pacific coast of the United States.

It has been noticed that storm areas approach these Pacific coasts as large depressions with a comparatively low energy of rotation around their centres. But when the area reaches the line of the coast or cascade range of mountains in Oregon and Washington territory, its outline is changed from the distorted circular to that of the irregular elliptical, and the northern end of the latter figure is carried toward the coast line more rapidly than the southern one, causing, as a rule, the first rainfall in the line of first contact with the land. Therefore, over Vancouver's Island and Western Oregon a rapid condensation of atmospheric moisture takes place which so

[1] Continued from p. 7.

speedily exhausts the air volume immediately affected by the storm of its humidity, that the lines of equal annual rainfall on this section of the coast are very close together, marking a decrease of precipitation inland. The energy of rotation increases here as the pressure at the storm centre falls. This energy concentrates at the northern end of the depression, and the area of low barometer is drawn, as it were, around the centre so formed as it passes eastward over the first range of mountains. After passing over all the intervening ranges of the great plateau toward the line of the Rocky Mountains in Montana and the British territory northward thereof, the storm as a moving atmospheric vortex is attended by only a very little rain or snow. The region over which it passes cannot furnish any supply of humid air, and the storm becomes again disorganised into a great depression during and after its passage over the mountains, until its centre has reached the eastern slopes. But here it enters a new region so circumstanced in its topographical relations with the east and south, as to derive a full and uninterrupted flow of humid air from the great river valleys, the lake regions, and the distant Gulf of Mexico. There are no intervening mountain barriers between these sources of humidity and the north-western prairies to interrupt the atmospheric flow toward the depression extending over them, but the storm reorganises slowly at first as the conditions necessary to induce a strong indraught of air to its centre are of very gradual development. When, however, they come into requisite combination, the indraught winds increase, and coming from the north-east and east, are deflected southward and south-eastward by the mountains, until a feeble but decided vortex is developed in the centre of the depression. The centripetal winds now begin to increase with the inflow of humid air, and the newly organised storm-centre moves eastward along its track, toward the region of the Mississippi Valley or the lakes. In doing so it descends the gradient of the plains through air of increasing density, and acquires greater energy every mile it advances. High pressures to the northward and southward of the storm-centre constantly feed it with fresh volumes of air, which being of different conditions of temperature and humidity, produce the rainfall that generally begins when the eastern margin of the depression enters the Missouri Valley. In the great region of the plains the storm finds free scope for development as well as an unfailing supply of atmospheric moisture. It usually attains its greatest energy when passing over Iowa, Illinois, Ohio, and Kentucky, toward the Upper Ohio Valley, and the narrow neck of territory between Lake Ontario and the Pennyslvanian section of the Alleghany Mountain Range. This mountain wall influences the course of the storm by deflecting it toward the north-east from the Middle Ohio Valley region, and thence over New England to Nova Scotia. The districts eastward of the Alleghany Mountains and southward of New York are rarely traversed by storm-centres coming as I have described, from the north-west, but receive the rainfall of the eastern margin of the storm as its centre passes north-eastward beyond the mountains, into the St. Lawrence Valley or the New England States.

But the mountains cause a profuse rainfall on their western slopes, and when the storm reaches the Atlantic the precipitation has been nearly exhausted. Its energy, therefore, decreases, when crossing from Oswego to Portland or Eastport, Maine, and does not recover until it receives from the Gulf Stream Region a new supply of humid air. I have endeavoured to describe the course of a storm-centre from the Pacific to the Atlantic, across the Continent, and have made no detailed explanation of the relation to its movement of the areas of high pressure. This I regard as of the highest importance, and will treat of fully under a special head. The course of the storm across the Atlantic, as well as its movement over Europe, will be governed only, I may say, by the high pressures. These being distributed from south to north, in a series of continuous, but movable zones, mark the directions of the storm's advance so clearly, as to enable an observer at this side of the ocean to predict with general accuracy, the section on the European coast on which the storm-centre will arrive, as well as the time of its arrival. Another type of Pacific storm is that which arrives on the southern and central section of the California coast as a great depression, and entering the continent, pours its rains over California, and becomes divided into two sub-areas of low barometer by the Sierra Nevada range. One of these sub-areas, and nearly always the largest, takes a south-easterly direction across Southern Nevada, into Arizona, and crosses the Rocky Mountains in New Mexico to Northern Texas, where it is organised into a storm in the same manner, but much more rapidly, as the previously described area crossing into Montana. The other sub-area passes from Central California to Idaho, and thence across the Rocky Mountains, into the Yellowstone River Valley in Montana, pursuing a track, thereafter, which sometimes brings the depression into the Lower Missouri Valley, but usually towards the Upper Lake Region. This sub-area of low pressure also becomes organised into a storm, but one of much less energy than that of Northern Texas. This can be accounted for by the fact that the crossing of the mountains by both sub-areas being almost simultaneous, the northern depression cannot receive any considerable atmospheric flow from the southward, as it is intercepted and drawn toward the southerly vortex. It sometimes occurs that the two centres of disturbance unite in a common depression west of the Mississippi River, but usually they preserve their identity, and become separated gradually by an intervening zone of relatively high barometer developed between them by their joint influence. The northern centre moves away to the north-east, over the lakes and Canada, with diminishing energy, but the southern storm centre advances into the Lower Mississippi Valley, and soon dominates the weather conditions over all the region southward of the lakes. In this position its isobars extend eastward to the Georgia coast, and even into the Atlantic, but the centre moves towards the Ohio Valley, westward of the Alleghany Mountains. The consequence is that a section of the depression near the Atlantic coast is cut off by the high range of the Alleghanies, and another sub-area is formed which is speedily organised into a distinct storm centre by the impinging of the ondraught winds from the east, north-east, and south-east on the mountains, in the same manner as I have already described.

As the centre of the main disturbance moves up the great central valley the subsidiary centre east of the Alleghanies moves with it, and where the mountains decrease in elevation the two centres draw towards each other so as to have a common encircling isobar of 29·60 inches, and sometimes even less. When they reach the latitude of New York, storms of this type commonly leave the coast between latitudes 38° and 42°, attended by an area of high pressure immediately to the northward, and followed by one from the south-west. The courses of these storms across the Atlantic are generally in comparatively low latitudes, and they arrive on the British Coasts from the west or south-west with moderate rains and winds backing from the north-east to the north-west.

Another type of Pacific storms is the one which originates in the tropical zone of that ocean, and strikes the Mexican coast, moving directly across that territory into Southern Texas, and along the Gulf Coast over Florida and Georgia to the Atlantic. The energy of such storms is frequently very great, and they retain, even after crossing the Mexican plateau, many of their original cyclonic features. When they move north-eastward through the Mississippi Valley they are always attended by heavy rains and electrical disturbances. Local storms or tornadoes are frequently developed on their south-eastern margins during the spring and summer months, and are always very destructive.

These Mexican storms, so called to distinguish them from the disturbances that move over Northern Texas from the California coast, will sometimes, but not often, cross the Alleghany Mountains from Tennessee to Virginia, and pass into the Atlantic northward of Cape Hatteras. Their courses across the Atlantic are generally southerly as compared with those of storms leaving Nova Scotia. They arrive on the British and French coasts from the south-west, but are now and then carried in a north-easterly direction, passing to the Norwegian coasts northward of Scotland, and thence over the Scandinavian Mountains into North-Eastern Russia and the Siberian Seas.

The cyclone, or great storm that originates in the equatorial zone of the Atlantic, by which I mean the region embraced between the equator and 15° N. lat., possesses characteristics which mark it as the most destructive atmospheric disturbance known to meteorologists. Of course these storms are developed in the equatorial zones of other oceans, but are not of such immediate interest to us as the Atlantic cyclones. I am convinced that the conditions which combine to develop nearly all areas of low pressure have an equatorial origin, the exceptional cases being due to local liberations of terrestrial heat during earthquakes and to the heating of volumes of air over great areas of sandy desert. North Atlantic cyclones may be divided into four classes, namely: Those that originate near the Cape Verde Islands and make their northward curves east of the 35th meridian, and do not affect the American coasts, but enter the European area over Morocco and Spain, passing eastward over the Mediterranean Sea. They are of comparatively rare occurrence. Secondly, those that originate about the 40th, and curve northward east of the 80th meridian, affecting the American coasts only by the induced marginal winds. Thirdly, those that originate immediately east of the Caribbee or Windward Islands, and perform their northward curves between the 80th and 90th meridians, so as to pass through the eastern part of the Gulf of Mexico, and over Alabama, Florida, Georgia, and the Carolinas toward the North Atlantic. Fourthly, those that originate nearer to the equator than the others referred to, and make the tremendous sweep from the middle of the ocean between the Venezuelan coast of South America and that of West Africa, over the West Indian Islands to the Texas coast, and there curving northward and eastward, sharply pass over the southern sections of the United States and into the North Atlantic from the vicinity of Cape Hatteras.

Of the first-named class of cyclones, little need be said beyond the reference already made. They represent the most serious dangers to be encountered by vessels bound to West African or South American ports, or passing over the Cape route to the Indian Ocean. The second class of cyclones, of which we have examples in the great storms of October 12, 1780, August 17, 1827, and August 12, 1837, and the later one as traced by the United States Signal Service Bureau, which commenced about August 18, 1873, take northerly courses. The only land station where these can be accurately observed is that at Bermuda; therefore information regarding their energy and movements must be collected from the logs of ships that cross their tracks. It is believed that these storms are developed only in the midsummer, and are not of frequent occurrence, but on these points we have very little reliable information. I am, however, inclined to accept the statement as to their infrequency.

The third class of cyclones we are more familiar with, because it embraces that type of equatorial storm which we most frequently experience. Examples from the earlier meteorological records are the storms of August 10, 1831, and October 6, 1846. With these we have the recent one of September 21, 1877, and which was signalled to London by the *Herald* Weather Bureau. The passage of this storm over the South Atlantic coast of the United States was attended by many disasters, wrecks, and inundations. Its course towards Europe was in comparatively low latitudes until it approached the Bay of Biscay, when it moved sharply north-eastward, causing heavy gales and rains, with thunder and lightning. The latter effects were very marked in Scotland.

The fourth class of cyclones, such as those of June 23, 1831, and September 27, 1837, and later on September 21, 1875, known as the great Galveston cyclone, are usually of extraordinary violence. Among the first successes of the *Herald* Weather Bureau was the correct prediction of the course of this storm when it was moving westward over the Carribean Sea. Only on one instance within my observation has a cyclone of the third class passed northward on the western side of the Alleghany Mountains, and then the storm exhausted its energy in Canada, but its depression, though much contracted, reorganised into a minor disturbance when it passed into the Atlantic, off the New England coast. The tendency of cyclones to lose their force by the extension of their area of low pressure is more decided than in any other type of storm. This will account for the low degree of energy in disturbances evidently of equatorial origin when they reach the Pacific coast of the United States and the coast of Spain. Unless the direction of the zone of high pressure along the south margin on which they move forms an angle of more than forty-five degrees with the equator, the storm has a tendency to pass through it, and in doing so expends much of its energy.

JEROME J. COLLINS

(*To be continued.*)

GAS AS FUEL

ATTEMPTS have been made from time to time to use gas as a means for heating; these attempts have more frequently failed than succeeded, chiefly by reason of the mechanical difficulties to be overcome.

It is pretty generally agreed that, on account of the ease with which the supply of a gaseous fuel can be regulated, the completeness with which such a fuel can be burned, the comparative readiness with which cleanliness can be maintained while using this fuel, and by reason of its high heating power, and for other reasons, gaseous fuel is to be much preferred to fuel in the solid form.

The most perfect gas for heating purposes would be that, the constituents of which should be all combustible, should be possessed of high thermal powers, and should produce, on burning, compounds of small specific heat. No gas which has yet been produced for use as fuel completely fulfils these conditions.

Common coal-gas contains such non-combustible bodies as carbondioxide and nitrogen, and among the products of its combustion is water, a body of large specific heat, and also requiring a considerable amount of heat to convert it into vapour. The complete combustion of coal gas also necessitates a comparatively large supply of air, and this, again, involves special mechanical appliances. Nevertheless, coal-gas has been proved to be, for certain purposes, a cheaper, more effective, and more easily managed fuel than coal, wood, or other forms of solid heat-giving material.

That steam is decomposed by hot carbon with the production of a gaseous mixture of considerable heating powers, has long been known, and several attempts have been made to utilise the products of this decomposition. These attempts have met with no great success on account of the cost of the plant required to work the manufacture and of the difficulties of the process. Long-continued experiments have, however, been carried on, and it would appear from a paper recently communicated to the Society of Arts by Mr. S. W. Davies, that these experiments have been crowned with a very fair measure of success.

The great difficulty was a mechanical one: it has been very simply overcome. Superheated steam is produced in a coil placed within a cylinder and is driven by its own tension in the form of a jet into the lower part of an anthracite fire. The jet of steam carries with it air sufficient to actively maintain the combustion of the anthracite; the gases issue at the top of the apparatus and pass into the mains. The fire is fed from the top by an arrangement which allows of the process being continuous. Water is forced into the coil under a pressure varying from 15 lbs. to 40 lbs. on the square inch. The whole apparatus is compact and simple.

The products of the decomposition of steam by hot carbon are mainly hydrogen and carbon monoxide; traces of marsh gas are also formed. Could these gases be produced free from admixed non-combustible bodies we should have a gas of very high heating powers. But the temperature of the glowing carbon must be maintained by the introduction of oxygen, that is, in practice, by the introduction of air. The problem how to introduce air sufficient to keep up vigorous combustion, and at the same time to maintain the decomposition of the steam, appears to have been satisfactorily solved; but the introduction of air means a lowering of the heating power of the gas produced, inasmuch as four volumes of nitrogen are brought in along with every volume of oxygen supplied. By passing the gas through a series o vessels containing hot carbon the nitrogen may be very much diminished in amount, and the heating power of the gas proportionally increased.

The gas produced by the decomposition of steam by hot carbon always contains traces of carbon dioxide which is non-combustible; the amount of this compound may, however, be reduced to 3 or 4 per cent. by regulating the depth of the layer of hot carbon through which the gases pass, and by maintaining the temperature of that carbon at a high point. But the maintenance of a high temperature throughout a mass of carbon can be accomplished, under the conditions of the manufacture, only by introducing a rapid current of air, which again means a dilution of the gas produced.

If, therefore, means could be found for feeding the anthracite fire with oxygen, a gas of very high heating power might be produced. A supply of oxygen at a cheap rate is a great desideratum; the gas exists in practically unlimited quantity in the atmosphere, but an easy and successful method for separating it from the nitrogen with which it is there mixed is still only hoped for by the chemical manufacturer. Were a supply of oxygen forthcoming, mechanical difficulties would present themselves before it could be utilised in the production of "water gas." The introduction of too small an amount of oxygen would mean the non-decomposition of the whole of the steam and the cessation of the combustion of the anthracite; the introduction of too much oxygen would mean the production of carbon dioxide in considerable quantity. But by regulating the size of the steam jet and of the blast-pipe, these difficulties might probably be overcome.

As the gas is now produced all danger of explosion is removed.

The heating effect of the gas as at present manufactured is about one-fifth that of ordinary coal-gas, for equal volumes; but the cost of the gas is so much less than that of coal-gas, that a given amount of heating work may be done—according to the figures given in the paper referred to—by using the new gas, with a saving of from one-third to two-thirds of the expenditure which would be involved were coal-gas employed.

Although the new gas is not perfectly adapted for the purposes for which it is to be used, yet there can be little doubt that we are now a step, and a very considerable step, nearer the final solution of the problem. Doubtless improved furnaces, and improved apparatus generally for burning the improved fuel, will be introduced.

The production of a cheap gaseous form of fuel is a great gain; so also is the invention of a means whereby the large stores of anthracite coal in this and other countries can be utilised.

Of all the forms of carbon experimented with in the production of the new gas, anthracite was found the best. Anthracite is difficult to burn; the ordinary forms of furnace do not admit of such a complete oxidation as is required in order to maintain the combustion of anthracite. But the blast of air carried into the gas generator of the water-gas apparatus by the steam jet insures the presence of a large quantity of oxygen, and therefore the combustion of the anthracite. Whether a simpler means could not be adopted for the combustion of anthracite is a question worthy of consideration. That a steam jet can be thrown into an ordinary furnace charged with anthracite, and the combustion of the coal be thereby insured, has been shown to be possible. Nevertheless, the production of combustible gas from the anthracite is to be preferred, for many reasons, to the consumption of the solid fuel.

The fact that we shall soon probably be in a position to make use of our stores of anthracite, is one of very considerable importance from an economic point of view. In possessing large quantities of anthracite we possess a a valuable commodity, but if we cannot realise a use for that commodity it ceases to be a source of wealth to us.

Further, large quantities of anthracite are known to exist in some of the British Colonies and in the United States; the utilisation of these would mean an increase in the commercial enterprises owned by Englishmen abroad, or supported by English capital; it would also probably imply an increase in the tonnage of shipping, and would thus tend to increase our "international wealth."

Whether it be regarded from the point of view of the chemist, or of the economist, the introduction of a cheap gaseous fuel manufactured from anthracite, marks a point of no little importance in the advance of manufacturing industries.

The experiments detailed in the paper by Mr. Davies show that the new gas is especially adapted for use in cooking operations in large private establishments, in clubs, hotels, barracks, &c. It is known that cooking can be more cheaply and more rationally conducted with the aid of gaseous than of solid fuel; if the new fuel does all that it promises to do, judging from the actual trials already made, its introduction will be welcomed by the artistic cook no less than by the scientific chemist, and by the political economist. M. M. PATTISON MUIR

FOSSIL FLORA OF GREAT BRITAIN

The Fossil Flora of Great Britain; or, Figures and Descriptions of the Vegetable Remains Found in this Country.

Illustrations of Fossil Plants, being an Autotype Reproduction of Selected Drawings prepared under the Supervision of the late Dr. Lindley and the late Mr. William Hutton, between the Years 1835 *and* 1840—*and now for the first time published by the North of England Institute of Mining and Mechanical Engineers.* Edited by G. A. Lebour, F.G.S. (Newcastle-upon-Tyne, 1877.)

THE publication, in 1831, of the first number of the "Fossil Flora of Great Britain," by Dr. Lindley and William Hutton, marked the beginning of a new era in the history of English Palæo-phytology. Much had been previously done on the Continent. The magnificent *Flora der Vorwelt* of Sternberg had laid a solid foundation for such studies, and the *Végétaux Fossiles* of Adolphe Brongniart, then in progress of publication, was not only widening those foundations, but was systematising the study, as his "Prodrome" had developed the first principles of the philosophy of the primæval Flora. The late Professor Phillips had further recorded additional discoveries amongst the Oolitic plants of Yorkshire, in his "Geology of the Yorkshire Coast"; but there yet remained a wide field for exploration, especially amongst the plants of the Carboniferous age, in which England was especially rich; and Phillips and Brongniart were very far from having exhausted the newly-discovered plants of the Yorkshire Oolites. Hence when the two able authors above named commenced the publication of their "Fossil Flora," they found a vast mass of new materials awaiting their investigation. In endeavouring to estimate the true value of their work, we must not regard it from our present standpoint, but from that of the time at which they began their labours. At that period, though collections of fossil plants were numerous, they were scattered over the country in isolated cabinets, and no one knew much about what those cabinets contained. Hence the first work demanding attention was to ascertain what the forms and general relations of these fossil plants were, and the pages of the "Fossil Flora" gradually gave the needful information so far as it was then obtainable. The two authors named figured and described such distinct fragments as fell into their hands, and thus made available for the students of a later period a vast mass of hitherto unknown material. This important publication went on for several years—but at length the two authors became weary of their costly venture. The number of persons actively interested in the study of fossil plants was not sufficiently great to cover the expense of the publication, which consequently came to an abrupt end. In 1839 the late Dr. Lindley told the writer of these lines that he saw no reason why he should employ his purse for the benefit of the geologists who failed to give him the needful support, and he acted upon the conviction thus expressed.

In endeavouring to measure the true value of the work of Lindley and Hutton to modern science, we must not forget the date of their labours. At the earlier part of the time when the publication of the "Fossil Flora" was in progress, little or nothing was known of the internal organisation of any fossil plants. But at length two instructive fragments were obtained in England—one of a Lepidodendron, and the other of a Stigmaria—both of which examples revealed a measure of minute internal organisation. Witham's "Observations on Fossil Vegetables," published in 1831, contained figures and descriptions of the first of these specimens, the now well-known Lepidodendron Harcourtii, and the Stigmaria was figured and described in the "Fossil Flora." These two specimens were the beginnings of a rich harvest, which is even yet but very partially reaped, but which has already prepared the way for a revolution in the processes and results of Palæo-phytological studies. But though the authors of the "Fossil Flora" thus obtained some glimpses into the possible future of their science, they did little more. Like good and true men they did the best they could with the materials within their reach. They found various dissimilar fragments of apparently distinct forms of fossil plants which they named, figured, and described. They thus introduced a certain degree of order and definiteness into what had hitherto been a *rudis indigestaque moles.* This work benefited not only contemporary but succeeding races of geologists. Such labours as these are the necessary preliminaries to the more exact determinations of more advanced science. Work like this has to be done in the early stages of every branch of natural science, and no great harm arises from the multiplication of genera and species, if we only keep in mind the fact that such nomenclature is but provisional;—a mere ticketing of special forms for convenience of future reference. The names do not indicate very much more than the fancy designations given to various "makes" of cloth in a Manchester warehouse—*i.e.* convenient terms by which the business transactions of buyer and seller are facilitated. Mischief only arises from this essential method when we make these provisional nomenclatures the basis of ambitious philosophical speculations; when, for example, because a plant is designated by the name of Palmacites, we conclude that Palms flourished in the carboniferous age. Keeping in mind the true use of a provisional nomenclature we find it indispensable to further progress. When some inquirer, more advanced than his predecessors, demonstrates that *Sigillaria A* and *Sigillaria B* are merely the upper and lower parts of a common stem, it is useful to him to be able to indicate by his terms A and B what the types are that bear this mutual relationship.

The *scientific* worthlessness of very many of the generic and specific definitions and names of fossil plants is now becoming obvious to all advanced students of Fossil Botany. Yet the assignment of these names and definitions to such fragments as fell in their way is the chief result of the publication of the "Fossil Flora." To the philosophy of the study its authors added very little. They left the supposed relations of the great types of vegetation to each other pretty much where they found them. They seem to have accepted equally what was true and what was false in the philosophy of Adolphe Brongniart. No one important discovery will be handed down to the future associated with their names. Fragments from various parts of the same plant took rank at their hands as independent species. Little or no attempt was made for variations due to age and conditions of growth. Nor were they to be blamed for this. We are still to some extent in the same predicament—only, thanks to the warnings of Sir Joseph Hooker and others, we now know what we have to aim at. We have to try to accomplish for plants what Burmeister did for the Trilobites. But if the use of merely provisional names is to be continued, it is very desirable that we should possess some means of distinguishing between such a nomenclature, and one that represents philosophic truths and may be employed as the basis and instrument of philosophical speculations. Nothing of the kind has yet been attempted beyond the "incerta sedes" of Brongniart. Yet I think it would not be difficult to invent some technical sign that would answer this end. For the present it can only be left to the judgment of each individual observer to determine what names are of scientific value and what are not.

But the most essential truth which these later days are teaching us is the importance of the study of internal organisation; and especially of that of the reproductive structures, if fossil botany is to take its proper rank as a definite science. Nothing can be more dangerous than a reliance upon mere resemblances or differences of external form. We have a ready illustration of this in the numerous verticillate-leaved plants of the Carboniferous beds. So far as mere external forms are concerned, Calamites, Asterophyllites, Sphenophylla, and Annulariæ, with a host of less known modifications, bear a close resemblance to each other—and if a few Galiums, Asperulas, and other similar living exogenous forms could have been thrown in amongst them they would probably have been equally undistinguishable from the rest. The result is that the nomenclature and classification of these Carboniferous plants is in hopeless confusion. True, we are slowly emerging from this chaos, because we are learning to distinguish some of these forms from the rest through their widely differing features of internal organisation—and every fresh plant in which we do so diminishes the bulk of the chaotic mass that still needs reduction to order. Though so much has already been done in this way, we are yet only on the threshold of the study. At the same time we are moving in the right direction. Such localities as Autun, St. Etienne, Oldham, and Halifax have furnished, and are likely further to furnish, important materials—each locality having revealed characteristic forms of vegetation peculiar to it, mixed with other forms common to all the localities. It is to be hoped that other similar storehouses will be opened out, revealing fresh forms of structural organisation, since it is upon organisation alone that a sound classification of fossil plants can be based.

The recent republication of the "Fossil Flora" is almost an exact fac-simile of the original work—even to its title-page. Copies of the old edition being rarely obtainable this re-issue will be valuable to a large number of young geologists. At the same time it is desirable that something should be done to distinguish between statements still to be relied upon, and such as represent now exploded errors. This might have been done by the introduction of editorial notes—but instead of this, its accomplished editor, Mr. William Carruthers, is about to issue a supplementary volume, giving the existing state of our knowledge of many of the objects represented in the original work. This may well be expected to constitute a valuable addition to the volumes already issued.

The second publication named at the head of this notice has an affiliated relationship to the "Fossil Flora." When Hutton died he left behind him numerous drawings of fossil plants, obviously prepared for publication, many of them having connected with them manuscript annotations of various kinds. A selection from these has been published in an elegant volume issued under the auspices of the North of England Institute of Mining and Mechanical Engineers. It is obvious that many of these drawings represent plants of more doubtful nature than the majority of those published in the "Fossil Flora." It might be expected that the more definite types would be first selected for publication. But this is precisely what appears to me to constitute the value of the volume in question. We have but too frequently, though very naturally, figured and described the more definable types, the more obscure and intermediate forms being left for a further consideration, which sometimes never comes! Yet these obscure examples often teach most important truths. Had all writers paid due attention to such intermediate varieties, the science of Palæo-Phytology would have been less afflicted with premature "classifications" than has been the case. Hence the spirited society that has published these posthumous Huttonian memorials is entitled to the thanks of all Palæontologists.

W. C. WILLIAMSON

TAXIDERMY

Practical Taxidermy; a Manual of Instruction to the Amateur in Collecting, Preserving, and Setting up Natural History Specimens of all Kinds. By Montagu Browne. (London: *Bazaar* Office, 32, Wellington Street, Strand. No date.)

ACCORDING to the dictum uttered, or supposed to have been uttered, by one of our leading ornithologists, "The worst use you can make of a bird is to stuff it," and in nineteen cases out of twenty this saying is true, for, from a real naturalist's point of view, comparatively little can be got from the stuffed and mounted specimen not only of a bird but of almost any other animal. Nevertheless, there is a very large class of persons who are not real naturalists, and to them the skin of a beast, bird, reptile, or fish, duly prepared and embellished with glass eyes, stuck up with wire through its legs in a glazed box, and surrounded by imitation foliage, dried and dyed herbage, is a joy for ever, though perhaps not even to them a thing of beauty. For this large class the present book is intended, and it will probably attain its object, notwithstanding that how far the animal stuffer's trade is to be learned from any book without actual demonstration seems to be questionable. The author's practical knowledge of his business is, we doubt not, considerable, and it would have been better had he let alone some of the matters not really relating to it upon which he descants. His very first sentence tells us that taxidermy "is derived from two Greek words, a literal translation of which would signify the 'skin art'"—a statement which beats the time-honoured explanation of Hippopotamus, from *hippos*, a river, and *potamos*, a horse, inasmuch as *taxis* has as little to do with art as with the Queen's taxes—and then goes on to inform us, from Herodotus, the *Penny Cyclopædia*, and other trustworthy authorities, how the Egyptians made mummies, which is all as delightful as so ghastly a subject can be, but is certainly somewhat superfluous as "Instruction to the Amateur" in "preserving and setting up Natural History Specimens." Hardly less unnecessary is Chapter II. devoted to "Trapping and Decoying Birds and Animals," whereby we may remark that the author is of that persuasion which denies the animal nature of birds. But we may pardon him this and other offences for what he says (pp. 14, 15) against the needless destruction of the rarer "birds and animals," and thence to Chapter X. is much more to the purpose. We are sorry to see, however, that he is addicted to the usual taxidermist's mannerisms, most of which are fatal to good and artistic mounting. Paint, for instance, however thin, *on* bills and legs is an abomination. If colour is required it ought to be supplied by subcutaneous injection, which in the majority of cases can be easily and successfully done. Artificial twigs of wire and tow, dusted over with powdered lichens and the like, are nearly as objectionable as the external application of paint. As regards the stuffing of heads of large mammals the instructions given are really good, but we suspect that a satisfactory result cannot be obtained without far more experience and closer study of nature than the author would have us think necessary. We must reproach him, moreover, for not giving a hint to the learner as to the best mode of preparing the "skin" of a bird so as to prevent its head from breaking off. This is done by inserting a long lock of cotton-wool of tow into the cranium (from behind, of course) making it fast there by tight packing, and then twisting the remainder of the lock into a kind of loose cord, which does not distend the skin of the neck, enables its length to be adjusted as may be required, and finally affords a coherent and effectual support, whereas the ordinary mode of ramming bit after bit of stuffing into the neck has exactly the opposite tendency.

Mr. Montagu Browne speaks with complacency of the achievements of English "artists" in taxidermy; but it seems as if his acquaintance with foreign works was limited to the comical creatures from Würtemberg in the old Exhibition of 1851. We venture to say that there is hardly a museum on the Continent which has not its specimens mounted in a style that no professional in these islands can equal—certainly not surpass. When we look at that really awful group of the boa and the peccary, recently erected in the British Museum, we blush for the handiwork and ignorance it displays. The impression it gives is that the boa, being crammed into a cylindrical form, is quite inflexible, and that the peccary, though not a learned pig, is fully aware of the fact, so, feeling sure that there is no chance of his being crushed by his enemy, he rather likes the adventure than not.

The question of the use of arsenic in preparing skins we cannot discuss at any length. Our author declares that *Tineæ* and *Dermestæ* laugh it to scorn, even if they do not, as he believes, like the Styrians, "fatten on it" (p. 44). We shall only say that we prefer it, and know of a case in which a collector in the tropics, having exhausted his stock of the poison, was compelled to prepare some of his specimens without it, which specimens were some years afterwards attacked and greatly injured by insects; while others, obtained before his store gave out, and duly arsenicated, remained unharmed, though lying side by side in the cabinet with the specimens that suffered. Arsenical soap, it is true, does not keep either feathers or fur safe, simply because it cannot be applied to them, but it certainly preserves the skin according to our experience, and every travelling collector should unquestionably use it. Corrosive sublimate is effectual for a time, but the best preventive is a well-fitting cabinet—care being taken that infected specimens are never introduced to it. In conclusion let us caution our readers not to be misled by the similarity of the author's name into confounding the present book with one on the same subject published many years ago by Capt. Thomas Brown.

OUR BOOK SHELF

The Gold-Mines of Midian and the Ruined Midianite Cities. A Fortnight's Tour in North-Western Arabia. By Richard F. Burton. (London: Kegan Paul and Co., 1878.)

CAPTAIN BURTON has managed to make a wonderfully interesting and really valuable book out of his fortnight's visit to the ancient land of Midian, on the north-east side of the Red Sea, on and to the south of the Gulf of Akabah. Long ago he had good reason to believe that in this region gold was to be found, but only in March and April of last year was he able to test his surmise, under the auspices and at the expense of the Khedive. The result of this visit is that he is satisfied that there exists a real Ophir, a regular California, extensively worked in ancient times, and whose valuable product is probably not unknown to the tribes who haunt it at the present day. Not only gold exists there, but vast deposits of iron, with copper, tin, and other metals—in fact a welcome treasure-house for the impecunious Khedive. Capt. Burton has hopes that modern Midian, now almost a desert, may yet rival the ancient land from whose people the Israelites, in the exercise of their divine vocation, carried off "the gold and the silver, the brass, the iron, the tin, the lead." Capt. Burton made a minute inspection of some of the ancient sites, and has a good deal to say on the archæology of the region, as well as its zoology, botany, and geology. But the book is not nearly all on the land of Midian. From the time that the author left Trieste for Alexandria and Cairo, by Suez to Midian, till his return, he saw many things on which, in his own digressive and parenthetical style, he has much to say that is worth listening to. Capt. Burton has just returned from another visit to Midian, and no doubt we shall soon have another work or an enlarged edition of the present.

To the Arctic Regions and Back in Six Weeks, being a Summer Tour to Lapland and Norway, with Notes on Sport and Natural History. By Capt. A. W. M. Clark Kennedy. Map and numerous Illustrations. (London: Sampson Low and Co., 1878).

THE title of Capt. Kennedy's pleasant volume is rather misleading; before looking into it we thought he would take us as far as Spitzbergen at least, and felt somewhat "sold" when we found his journey ended at Tromsö, in the north of Norway, which, though within the Arctic Circle, is not usually spoken of as in the Arctic Regions. Still Capt. Kennedy's book is thoroughly readable, and though it will add little to our knowledge of Norway or of the Lapps, will prove valuable to any one contemplating a visit to that now much-frequented tourist ground.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

Eastward Progress of Terrestrial Magnetism

As the progress of weather eastwards is one of the subjects now engaging attention, while the possible connection between meteorological and magnetical phenomena is another, we are led to ask if there be no traces of an eastward progress in certain of the phenomena of terrestrial magnetism.

I cannot yet affirm that such is the case, but it may interest your readers to know that, as far as a preliminary investigation goes, there are some indications of such a progress when we compare together the Declination-ranges at Kew and at Trevandrum. It will, however, require a more thorough discussion before the fact can be considered as at all established.

Manchester, May 4 B. STEWART

The Phonograph

SINCE writing my former letter on the phonograph (NATURE, vol. xvii. p. 485) I have had the advantage of seeing some of the work that Prof. Fleeming Jenkin is doing with his own instrument, which must, I think, be more sensitive than the one I examined. This work convinces me that the phonograph has already risen beyond the rank of lecture illustrations and philosophical toys, to which I assigned it in my last, and that it promises to lay some permanent foundations for the more accurate investigation of the nature of speech sounds. Prof. Fleeming Jenkin, by a most ingenious arrangement, which I must leave him to describe in his paper to the Royal Society of Edinburgh, obtains vertical sections of the impressions made on the tin-foil by the point of the phonograph, magnified 400 diameters. Some of these original tracings I had the pleasure of seeing yesterday, and they are full of interest. I have termed them "speech curves." They differ considerably from the phonautographic speech-curves of Léon Scott and Koenig, which only succeeded with the vowels, and from the logographic speech-curves of Mr. Barlow, which only succeeded with the consonants, in so much as they succeed with both. In such a word as *tah*, for example, intoned rather than sung, but not simply spoken, as the vowel would otherwise not last long enough for subsequent study, we have first the "preparation," in which the curve gradually, but irregularly, rises, then the "attack," where there is generally a bold serrated precipice, with numerous rather sudden valleys; next the "glide" where there is a perfect tumult of curvatures arising from the passage of voice through a continually changing resonance chamber, producing a rapidly and continuously changing but indistinct series of vowel sounds, which gradually settle down into the "vowel" proper. In the vowel, if well intoned, the curve remains constant for a considerable number of periods, beautifully reproducing itself, but, as the intoner becomes exhausted, "vanishing" away gradually to silence, the distinctive peculiarities of the curve disappearing one by one, till a dead level is again reached.

Then Prof. Fleeming Jenkin subjects this vowel curve to "analysis," reducing it to the separate "pendular" curves of which it can be composed. This corresponds to determining the "partial," tones (*parzialtöne, theiltöne* of Helmholtz, of which all but the lowest are called *oberparzialtöne, obertheiltöne,* and by contraction *obertöne,* whence the unfortunate English word *overtones,* which is constantly confused with *partials,* thus assuming a part for the whole) out of which the whole "compound" tone is formed. The first two partials are much stronger than the rest, the second often stronger than the first (hence the frequent confusion of octave?), the others generally very weak, although exceptionally one of the higher partials may be stronger. As many as five partials, as far as I remember, were traced out in the analysis Prof. Jenkin showed me, which he had just received from Edinburgh. The results differ materially for different speakers. Also there is a peculiarity in the "phase" with which the different partials enter into combination. Helmholtz showed that this difference of phase would materially alter the form of the curve, but would not alter the appreciation of quality by the ear depending upon the actual partials and their degrees of loudness alone.

The phonograph, as I have said, resembles rather a worn "print" than a "proof" of the human voice. This means, of course, that the delicate upper partials, on which all brilliancy depends, are absent. In some respects this is advantageous for the very elaborate inquiry which Prof. Fleeming Jenkin has instituted, for it enables him to catch the bold outlines on which genera depend, without being at first bewildered by the delicate details which give specific differences. Our speech sounds are, of course, individual, and what is recognised as the same speech sound varies in the same speaker within the limits of its genus, almost every time it is used. We shall do much if we establish the genus. The extent of Prof. Jenkin's researches, as he contemplates them, and the care with which his initial experiments, tracings, and analyses have been conducted, lead us to hope that we have at least got an instrument which will enable us to solve the elementary problems of phonetics that have hitherto almost baffled us, although it is not suited, as yet, to fix those delicacies of utterance which were my own special object of investigation.

April 30 ALEXANDER J. ELLIS

ON repeating the experiments with the phonograph narrated by Mr. A. J. Ellis in NATURE, vol. xvii. p. 485, upon a different instrument, I have found the results of my experience to differ in several respects from his. Doubtless each instrument possesses its own individual characteristics; hence it will be the more needful to exercise caution with respect to generalisation, especially as the existing instruments are few and in the hands of few observers. Mr. Ellis has been careful to state the nature of the instrument with which his results were obtained, and the name of Mr. Stroh is a guarantee for the construction of the mechanism. The instrument with which I have been working is of homelier make, and not provided with a driving-train or governor, but simply turned by hand. The same disc—a three-inch ferrotype plate—serves as receiver and transmitter of the voice. The foil used has been, if anything, a little too thin for the purpose.

On trying the sounds *aabaa*, *aadaa*, &c., I found the consonants clearly distinguishable, except the sibilants. *Aajaa*, which is stated by Mr. Ellis to be faultily delivered by the instrument, was perfectly recognisable, and could be distinguished from *aadaa*. Neither was there any confusion between *jack* and *dack* or *tack*; but *jacques*, with the soft *j*, was sounded out by the instrument as *hăāk*. My phonograph makes the clearest possible difference between the words *bout* and *bite* when carefully spoken, the diphthongal sounds coming out beautifully as *băāōōt* and *băāēēt*. On reversing the motion of the handle, *tēēăāb* and *tōōăāb* were unmistakable. The double nature of some of our consonantal letters is very clearly demonstrated by this process of reversal of motion, as Messrs. Fleeming Jenkin and Ewing have already shown. To the sounds they name let me add that of *ch* in the word *cheque*, which we ordinarily pronounce *tshek*. This word gives a very peculiar sound when reversed in the machine.

The greatest difficulty—that of getting an instrument to acknowledge the sibilants—is a difficulty that all who have worked with phonograph, phonautograph, or telephone, admit. The remedy mentioned by Prof. Mayer, that of using a mouthpiece with a very small hole, has the inconvenience of diminishing materially the loudness of the articulation of the machine. I have found it better to fasten a strip of card or watchspring across the opening, edgeways, so that the voice impinges on the edge of the strip. With this device sibilants are improved; the word *scissors* becomes practicable, though "*Scots*" is still intractable. One of Mr. Stroh's instruments, which was shown at the Crystal Palace during Easter week, gave *s* and *z* fairly. In a familiar phrase the *s*es are not much missed: *Steady, boys, steady*, is given with less marked defect of speech than if uttered as *thteady, boyth, thteady*. Another point of interest that has not, I think, been yet mentioned by observers is, that the marks corresponding to the vowel sounds differ when the mouth is at different distances from the vibrating plate, but that yet there is no difference in the vowel subsequently emitted by the machine; a result which confirms the previously known independence of the vowel sound of the phase of its component partials. For some time I thought my phonograph guilty of dropping its *h*'s (though not made within the sound of Bow bells), but when that letter is spoken rapidly in a word it is recorded faithfully. *Happy land* is well heard in the instrument; and *How do you do?* is also aspirated. Curiously enough, this sentence is spoken almost as well backwards as forwards (except the aspirate), especially if spoken to the machine with a strong Scottish accent. It is remarkable how useless an instrument without a clockwork regulator is for reproducing even the simplest airs: they are simply lost in noise. Altogether the study of speech by the phonograph is most interesting, and will furnish some most valuable data to students of language and of acoustics. It is impossible to witness its performance without a tribute of acknowledgment to the extreme ingenuity and skill of its inventor, Mr. Edison.

SILVANUS P. THOMPSON

University College, Bristol, May 1

On the Use of the Virial in Thermodynamics

THE ingenious experiment and the deductions from it, described by Mr. S. Tolver Preston in NATURE, vol. xvii. p. 31, throw a flood of light on the subject of availability of heat-energy, which altogether alters the basis upon which the hitherto imperfectly expressed conditions of the use of this form of energy will be made to rest. Mr. Tolver Preston has, in fact, discovered that discriminating "sprite," or being whom Prof. Clerk-Maxwell imagined ("Theory of Heat," 1875, p. 328) singling out the fast-moving, and separating them in a space by themselves (without any expenditure of energy), from the slow-moving molecules of a gaseous mass; or what is nearly equivalent to this, he has at least shown how *some* fast-moving and *some* slow-moving particles of a mass of gas originally in equilibrium, both as to temperature and pressure, *will naturally* be so guided amongst each other, that their joint energy will become more available than it was before. But it has, perhaps, not occurred to Mr. Tolver Preston and to some of your readers, that this power or faculty of rendering heat-energy available, which mutual diffusion of heterogeneous gas-masses, either through a porous septum or in their own contiguous layers possesses, is a consequence of the general form of efficacy belonging to force, of which Prof. Clausius pointed out the existence in his important propositions on the "virial,"[1] as he has termed one of the two members, of which this kind of mechanical tendency of force is the sum. The other member of a force's "*radiality*" (as it may be termed) "with respect to a given point," is the *vis viva*[2] of the material particle upon which it acts, in a space of which the selected point is the origin. In description of this newly-discovered natural tendency of a force with respect to a given point or focus, it is enough to say that while the statical *moment* of a force, or the product of the distance of its point of application from a point or fulcrum by the resolved part of the force perpendicular to this distance tends to increase uniformly the *moment of momentum* (defined similarly with that of *force*) of the particle upon which it acts, so does the "radiancy" of a force, or the product of the distance of its point of application from a given point or "focus," *together with the vis viva* of the particle upon which it acts, tend to increase the "radiancy of momentum" of the particle described in the same way as the radiancy (or the first term of the radiality) of the force, as just defined. We may speak of the radiancies of equal and opposite reactions, or of force-pairs, in the same way that we deal in statics with the moments of couples; with similar general properties of their equilibrium, including the resolution of the total radiancy (like the impulse, the horse-power, and the moment) of a system of forces, into an internal and an external part with respect to the centre of mass of a material system upon which it acts; and there are principles of conservation of moment and of radiancy of momentum about any point, taken as centre, of all the force-pairs whose moments and radiancies balance each other on a material system. Only the system's *vis viva* referred to the centre is in the latter case the rate of change of its radiancy of momentum relatively to it. It is in the same way that the conservation of the motion of the centre of mass, and the conservation of energy, are principles of nullity or of inaction of two other forms of force-agency balancing each other on a material system (the impulse of forces, and the product of their impulse by the virtual velocity of their point of application, or their "horse-power") to which we are obliged to have special recourse to resolve the particular varieties of questions of the "transfer of energy" which occur in mechanics. But it is remarkable that the radiality of a force-pair includes the *vis viva* of its mass-couplet as one member of its mechanical efficacy, and a surprising example of an agent (evidently the agent of heat-distribution) here presents itself in which *vis viva* itself is one of the active elements of the mechanical variation or compulsion! Its total tendency in any body acted on internally only by directly reacting force-pairs is the total *vis viva*, and the sum of the virials of those force-pairs, diminished, if the body is subjected externally to a uniform pressure normal to its surface, by three times the well-known product of this latter pressure by the volume of the body (written $-3pv$).

[1] *Poggendorff's Annalen*, vol. cxli. (1870), p. 124. But Clausius, it should be remarked, gives the name "virial" *to half* of the quantity which I have described below as the "radiancy" of a force. An exposition of Clausius' new mechanical expression, the virial, with an explanation by its means of the process of condensation of vapours into the liquid state, was given by Prof. Clerk Maxwell in his lecture to the Chemical Society on the molecular theory of the constitution of gaseous and other bodies, in 1875. (See NATURE, vol. xi. p 357.)

[2] Using this word for *twice* the quantity usually described as a particle's "kinetic energy."

In the mutual inter-diffusion without change of temperature of two gases of different densities through a fixed porous diaphragm, although no energy is withdrawn from or communicated to either of the gases, the rate at which single molecules take their equal measures of gas volume through the partition being very different, like their velocities, the measure of gas-volume which accumulates on the side of the denser gas soon raises the pressure there, increasing the intensity of the mechanical tendency $3pv$ on that side of the partition, while the same kind of mechanical tension diminishes on the other, and the temperature on each side of the partition is at the same time unaffected. As the porous diaphragm by its immobility (which prevents one of the sets of molecules from doing any work upon the other) resists the resulting force upon it, its counter-tendency is entirely derived from the increase of its own external virial, which has sprung up (at no expense of work, supposing the diaphragm to be perfectly rigid) in maintaining everywhere in spite of their impacts the common temperature or mean energy of both sets of molecules. Were the diaphragm away, it is evident that the rapid flow of rare gas-volume across the confines between the two gases towards the denser side would cause the centre of mass of the gas-layer, in which the mixture begins, to move bodily away from the denser gas, just as the diaphragm would do if it were free to move; and the *bodily motion* so given to the medial gas-layer will, as a form of external radiality in the layer, arising from the heterogeneity, require, in order to be constantly neutralised in the whole body of the mixing gases, such a redistribution of their temperature and density to be taking place at every instant throughout the two bodies of gas placed in communication, that their centre of mass as a connected (but otherwise *isolated*) system may never undergo any change of place during the mutual diffusion. The space originally occupied by the rarer gas will accordingly become the hotter, and that by the denser the colder portion of the whole volume which the gases continue to occupy when they are mixed.

It is in the same way that we can explain the action of regenerators in such air-engines as Stirling's and Ericson's, in passing through which gases change their temperature and volume (and therefore their tendency or "radiality," $E - 3pv$), at constant pressure, the counter-tendency being at the same time lodged or relaxed during the process in the regenerator, where it must be kept by non-conduction in the *tense* state (of actual heat-energy and virial combined) of "radiality" (corresponding to the similar "heat-tension" of the gas by which its heat-energy exchanges are secured. The property of the usual non-conductivity required in the regenerator, is one of indifference of the molecules of a substance to the radiality (or to the sum of the sensible heat and the virial), of neighbouring molecules, or in which different values of the quantity $E - 3pv$ of small neighbouring parts of the substance equalise themselves with difficulty through the mass. But perhaps it is not the inter- but only the *intro*-molecular forces that furnish the radiality (and "virial") that determines the transmission of heat? If the former forces balance each other, which they do when the body is not vibrating by its elasticity, the virial of the intro-molecular forces only, together with the *vis viva*, may be "conservative" with regard to heat-energy, and may be employed in its transmission? Since radiancy of momentum is not heat-energy, we see that this natural effect of force radiality, or of virial and *vis viva* combined, can only be converted finally into actual heat-energy by some mechanism peculiar to the molecular structure of the solid and liquid bodies in which the heat-energy transmission takes place. Some kind of heat-engine apparently effects this process, for example, at the confines between the vapour and the liquid, when steam is condensed into water, but it is certainly a non-reversible one when the water-spray is colder than the steam which it condenses; and in the conduction of heat by solid bodies the process is also a non-reversible one; we only know the part which sensible heat, as temperature, or *vis viva*, acts in promoting heat conduction; and the virial by which it is perhaps also carried on, and which with *vis viva* conserves radiancy of momentum, may also be a fellow-regulator of the operation of which we have no certain knowledge, and over which we certainly have no direct control. But that it should invariably tend to lower the availability of heat, by heat conduction among the comparatively fixed molecules of liquid and solid bodies, will not, perhaps, when the internal motions of molecules are better understood, be more difficult to demonstrate from some theory of its action, than that it should sometimes serve to raise the availability of thermal energy by its action on heterogeneous gas masses. A. S. HERSCHEL

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P.S.—Maturer reflection, since the first impression of surprise which Mr. S. Tolver Preston's announcement of the new experiment to which it relates caused me to express at some length, and perhaps unguardedly, in this letter has shown me that the properties of the virial, easily as they may conduct to some important results, do not, in this case, supply a complete solution of the problem of the final state of two gas masses at the same pressure but of two dissimilar densities on temperatures left to diffuse into each other in a confined space. The equal pressure on all parts of the inclosure predetermines the fixity of the centre of mass during the process, and consequently an unequal distribution of density, and therefore of temperature finally, when the mixture is complete; but the equation of the virial or the principle of conservation of the radiancy of momentum supplies no certain information what must be the law of this final distribution, one of its terms, $3pv$, or the virial of the inclosing pressure, being capable of undergoing unknown variations during the progress of the diffusion; and although the stationary condition of the mass at last implies that this term will not be permanently changed, yet both its value and that of the system's total moment of inertia round its centre of gravity (the *acceleration* of whose magnitude is the rate of change of the radiancy of momentum) may vary in the interval, with the result of leaving the latter moment of inertia permanently altered to an extent and in a way which cannot be defined. When in the simple case of a perfect gas the condition of the virial fails to afford positive information regarding the law of conduction and transference, or of rest and repose of heat in them under various distributions of temperature, it can hardly be expected that the same principle will furnish useful and definite results regarding heat-transmission through solids and other kinds of bodies of which the modes of molecular aggregation are almost totally unknown. A. S. H.

Time and Longitude

THERE is an old and instructive problem which I have lately propounded to several people, and have been struck by the great variety of answers given to it.

Although we often lose sight of the fact, it is nevertheless true that any given day or year does not begin all over the world at the same moment, but, commencing first at some point in the east, it travels round westward with the sun, so that two different years are often coexistent at the same moment, and it is easily possible for two events to occur a few hours apart, and yet that which happened first to occur in 1878, and the later event in 1877. In the same way each day of the week starts somewhere to the eastward of us and dies somewhere in the west. Taking, then, any given day of the week as Monday, the problem is—When and where did last Monday first commence, where did it end, and how long did it exist? Or, to put a similar question, Where did the year 1878 first commence, and at what Greenwich time?

I will simply state my belief that last Monday commenced in New Zealand somewhere about noon on Sunday, but not at noon, its commencement at that time and place being in no way connected with its position as our antipodes, but being a mere accident of civilisation. If the whole northern hemisphere should become civilised and inhabited, the day would then almost certainly commence at Behring's Straits, and would last forty-eight hours. A person crossing Behring's Straits east or west would gain or lose a whole day just as he now does by sailing round the globe; so that he might easily cross over and spend a few hours of to-morrow with his friends and return in time for dinner, or might enjoy the New Year's Eve on two successive days.

If the Pacific Ocean became inhabited land, a meridian would have to be chosen as a starting point for the day, and a person stepping across this imaginary line would gain or lose a day. At the same moment that Sunday morning was commencing on the one side of this line, Monday morning would be commencing on the other, and there would be constantly two different days going on side by side with twenty-four hours' difference of time between them, though only a few yards apart. It would be possible for a person standing astride this line to have for an instant one foot in Monday morning, the other foot in Monday night, and his body in the previous Sunday.

I purposely avoid giving any reasons, and do not assert that all my views are correct, but I throw out the problem as an amusing one for argument and discussion, as it abounds in apparent paradoxes. At the same time it cannot fail to be instructive. LATIMER CLARK

May 7

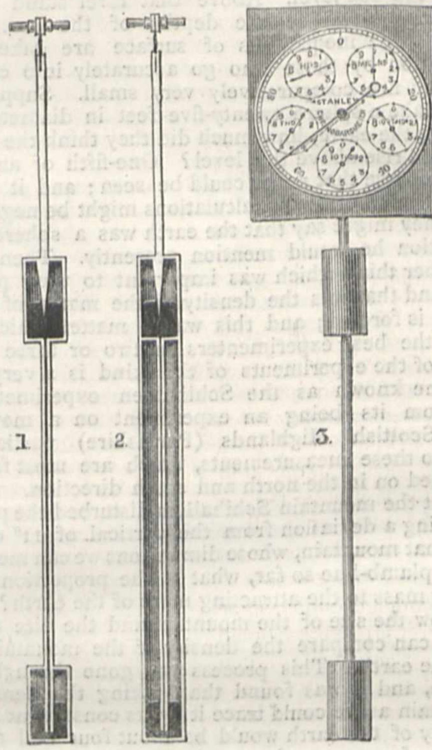
Cumulative Temperature

ATTENTION has been called in your valuable paper to the idea of registering cumulative temperatures by means of a pendulum, by M. von Sterneck, vol. xvii. p. 308, and this has called forth several letters. One gentleman has put forward my name as having devised means with some success. In an instrument exhibited at the Royal Society *soirée*, 1876, I could have left the matter resting at this point, but I am induced to write by the letter of your correspondent, "B," in vol. xvii. p. 486, who says, "The chief merit in this matter will belong to the person who puts the idea into a working form which can be proved capable of giving accurate results." As I think that I have fairly attained this end, or at least pointed out the way to it, with your permission I will describe the means which appears by the correspondence interesting to many of your readers. In my cumulative temperature clock the important element, the *pendulum*, is constructed as follows:—A steel cylindrical tube 32 inches long, $1\frac{3}{4}$ inch internal diameter, is hermetically closed at both ends. A rod is attached to one of the ends, which is placed uppermost, to connect this pendulum with the clockwork in the ordinary manner. An air-tight division is made across the tube or chamber at 5 inches from the upper end. A small tube leads from this division to the bottom of the chamber. A conical plug is inserted in the upper chamber, to be hereafter described. A screw plug is placed under the small tube in the outer tube to enable the upper chamber to be filled with mercury. When the pendulum is so constructed, the lower screw plug is removed, and the upper chamber and leading tube filled with mercury by means of a small funnel. In this full state the mercury is boiled, and the whole inverted. It then becomes a steel *barometer*. To convert it into a thermometer, a small air-hole is made in the outer tube (this is not shown in the engraving), and this hole is closed up with a small air-tight cock filled with a porous material. When this is screwed on and turned off, it is isolated from atmospheric pressure, and the mercury rises into the upper chamber by any increase of temperature causing expansion of air in the tube, and sinks in the same manner by loss of temperature, so that the pendulum becomes simply an air thermometer. The pressure of the air by expansion within the tube in the rising of the mercury changes the centre of oscillation of the pendulum and accelerates the clock, and *vice versâ*.

The clock is specially constructed to count beats only in units, tens, &c., up to ten millions, and the number of beats per day, week, month, or year, becomes the unit of temperature for the period. The exact length of time of each pendular oscillation being governed by the temperature at the time, the method becomes equal to one accurate observation at every second of time.

The difficulties of construction and refinement required upon this general description are of two kinds, mathematical and mechanical. The models that I exhibited at the Royal Society's *soirée* were imperfect, being of blown glass. The difference of oscillation per day for 1° Fahrenheit, was in these about 50, as taken at the Lambeth Observatory by the late Col. Strange. In the steel instruments described there would be about 100 oscillations additional per day for the rise of each degree centigrade. The mechanical difficulties are simply constructive. To obtain perfectly vacuum proof chambers, and to follow correctly the outline of the plug to be immersed in the vacuum-chamber. Also the adjustment of the correct volume of mercury, and the density of the contained air, by means of the cock, and the application of heat or cold to the outer case. The mathematical requirements are corrections. Thus: if the chambers were simply cylindrical, the mercury that rose by the pressure would have a different oscillation value for every point of space through which it rose. This might be corrected to equal scale value by making one or both the mercury-chambers conical, but it is much more simply done by inserting a conical plug in the upper chamber. There would also be a correction for the expansion of the mercury and the steel case, and from any irrationality in the expansion of the contained air. The whole of this correction being derived from heat might be made by one correction in the immersed plug. Prof. Stokes, Sec. R.S., kindly offered to calculate the exact form of this plug for me from data I was to supply. But I was ill shortly after this, and unable to attend to the matter, so I let it drop, but have the clocks and pendulums ready to complete some time hence.

I send a diagram engraving which shows the principle of the pendulum No. 2, for cumulative temperatures. No. 1 is for taking cumulative pressures upon the same system, if the science of meteorology should require such exact means of obtaining permanent records of pressure and temperature for long periods as for months or years. WM. F. STANLEY



South Norwood, April 22

THE INTERIOR OF THE EARTH [1]

SIR GEORGE AIRY remarked that the nature of the subject was different from any upon which he ever lectured before, in regard to its indefiniteness and to the difficulty he should have if he considered it to be his duty to lead them definitely up to some point. He could only give them some idea of the theory to which he wished to lead them, and in doing so he would advert collaterally to a good many points which might be valuable. He proposed to divide his address into three parts. The first would relate to the measures of the earth; the second to observations on temperature; and the third to the manner in which they might suppose the earth to have been formed, especially with regard to the nebular hypothesis; and after that he would add some remarks on the conclusions to which these lead.

He described the process called triangulation, by which a large part of the contour of the globe is covered, and by which it is possible to lay down a map on which the distance between any one point and any other point is ascertained to within a few inches; how that this was valuable in ascertaining the dimensions and figure of the earth with the aid of the zenith sector, an instrument for measuring the apparent distances of stars from the point overhead. He showed on a large globe the principal lines of measurement which had up to this time

[1] Abstract of Address at the Cumberland Association for the Advancement of Literature and Science, by Sir George B Airy, K.C.B., F.R.S., Astronomer-Royal. Revised by the author.

been made for this purpose. From these measurements, there was no doubt that the earth is very nearly a sphere of 8,000 miles in diameter, or 25,000 miles in circumference. When he spoke of the surface of the earth, it must be understood that he spoke of the sea-level. Above that level stand mountains, and below are the depths of the sea. But although these inequalities of surface are taken into consideration by those who go accurately into calculations, they are comparatively very small. Suppose he were to make a sphere twenty-five feet in diameter, representing the earth, how much did they think the mountains would rise above the level? One-fifth of an inch. Well, of course that never could be seen; and it was a thing that in all ordinary calculations might be neglected. So that they might say that the earth was a sphere, with an exception he would mention presently. Then there was another thing which was important to their present subject, and that was the density of the matter of which the earth is formed; and this was a matter which had engaged the best experimenters in two or three ways. The first of the experiments of this kind is a very celebrated one known as the Schihallien experiment, so called from its being an experiment on a mountain in the Scottish Highlands (Perthshire) particularly adapted to these measurements, which are most favourably carried on in the north and south direction. It was found that the mountain Schihallien disturbed the plumb-line, causing a deviation from the vertical of 11″ or 12″. Then if that mountain, whose dimensions we can measure, turns the plumb-line so far, what is the proportion of its attracting mass to the attracting mass of the earth? And as we know the size of the mountain and the size of the earth, we can compare the density of the mountain and that of the earth. This process was gone through with great care, and it was found that, taking the density of the mountain as we could trace it by its constituent rocks, the density of the earth would be about four and a half times that of water, or about twice the average density of the surface rocks. The earth had density everywhere, but was more dense towards the centre than the outside. The next experiment is known as the Cavendish experiment. Here was a very light rod of deal, six feet long, suspended by a fine copper or silver wire (which is the most delicate suspension we can have) forty inches long, within a wooden case to defend it from currents of air. At each end of the lever was hung a ball two inches in diameter, and by a simple contrivance a pair of leaden spheres, weighing together perhaps 300lbs., were brought simultaneously into the neighbourhood of the balls (but outside the case), on opposite sides, so that they might attract the small balls; and the experiment was varied until, by a series of calculations, the density of the earth was ascertained, and gave a greater result than before, namely, that the average density of the earth was about 5½ times that of water. Then the third experiment was one which he made himself in the Harton colliery, near South Shields. That was by seeing how much the force of gravity was altered by going to a great depth, the force of gravity being ascertained and compared at the top and bottom by the swinging of a pendulum. From that a calculation was made, and it gave the density of the earth as six times that of water. He believed the best calculation was that founded upon the Cavendish experiment, and was quite willing to take something like 5½ times the density of water as the average density of the earth, including every part of it. There were consequences which followed from that which were certainly very striking. As this density was rather more than double that of the surface rocks, it showed that towards the centre the earth was more condensed than at the outside. But there was one result of the calculation which rather startled him when he made his own experiment on the subject. Since these rocks press upon each other more and more the further you go down, what is the pressure upon the square inch when you approach the centre of the earth? Many gentlemen there would have heard of a pressure of 50 lbs. or 100 lbs. on the square inch, and perhaps the greatest pressure we know is that by which tough Aberdeen granite is crushed—10,000 lbs. to the square inch. But it must be 30,000,000 lbs. to the square inch in the centre of the earth; and it is an astounding thing to imagine what consequences may follow. We have no idea of any such degree of pressure, and cannot therefore conceive what its consequences may be. Perhaps thereby gas may be squeezed into gold or platinum, and powder to solid, or solid to powder—we cannot tell what it does. That enormous pressure, and our total ignorance of it, is one of the difficulties and troubles of this case. He thought the general state of the earth would be understood from what he had said, and now he came to the rotation of the earth. The earth revolves, as everybody knows, in the course of a day; and everybody knows also, from the housemaid who whirls her mop to the greatest philosopher, that rotation will swell out the middle of the earth. Calculations have been made upon that, and the result is that the diameter of the earth in the equatorial direction is greater by about 1-300th part than the diameter in the polar direction. When they found that the measurement of the dimensions of the earth agreed so well with that conclusion, it led them to the further conclusion that the earth is, or has been, in a fluid state. In corroboration of this, he would mention a singular circumstance which occurred in our Indian Survey. In proceeding northward from Cape Comorin, the curvature of the earth agreed very well for many hundreds of miles with that found in other parts of the earth (with due reference to the elliptic form of the earth). On approaching the Himalaya Mountains, the plumb-line was sensibly attracted by the mountains. The late Archdeacon Pratt investigated, from the form of the mountains and the density of the rocks, the disturbance of the plumb-line, and found that it ought to be much greater than it really is. Sir George explained this by supposing that the whole of that country is floating upon a dense fluid, and that the thick mass of the lighter mountain-matter sinks deep in the fluid, and that the displacement of denser matter neutralises almost entirely the attraction of the lofty mountains. The form of the earth is not such as would be taken by a solid structure, but such as would be taken by a fluid mass with solids floating upon it.

In the second part of his address, Sir George Airy referred to what is known about the temperatures. They knew something of the rate at which temperature travels through the earth. The experiments on this point had begun, as many good experiments have begun, with the French, who fixed thermometers with very long stalks to the depth of twenty-five feet in the ground. These experiments were followed up, after some time, with similar thermometers at the Observatory at Edinburgh, and about the same time at the Observatory at Greenwich, and there the deeper thermometers were read every day. The first and most conspicuous result of these experiments is the retardation of the seasons. At the depth of twenty-five feet, high midsummer heat occurs at December, which shows that it takes five months for the heat to travel down that depth. If you compute it further, it takes 100 years to travel a mile; so that if the crust of the earth is 100 miles thick, it will take 10,000 years for the transmission of heat through it. This showed that really, after all, we may have a great deal of heat below us, and that it will not come to us for a very long time. It will come at last, but it will come travelling up slowly, and in the meantime the radiation from the surface of the earth will carry it off very rapidly. So that it is quite possible that with a cool surface there may be a great deal of heat below. In every part of the earth there is evidence of intense heat in former times.

The extent of volcanic action is partly lost on the earth by the effects of air and water; but when they looked at the old rocks, they found there had been volcanic action almost everywhere. In our limestone rocks, for instance, there are the basaltic veins, which in some parts go by the name of toadstone, which are certainly the result of volcanic heat enough to produce fluidity. Almost everywhere they found that there were volcanic streams intermixing with all the rocks; and even although the surface of the earth had been free from volcanoes in a given district for a time, yet there had always been volcanic action very near, enough to force in veins of lava from time to time. It seems, therefore, that we are entitled to say that we have always been near a great deal of heat—probably we have been much nearer it than at the present time, but still we are near enough to experience a great deal even in these countries. Repeated experiments have been made on the increase of temperature as you go down in mines, and the conclusion has been come to that the temperature rises one degree Fahrenheit, sometimes in sixty and sometimes in 100 feet. There is a mine in Cornwall in which he had walked in a stream of water at the bottom actually scalding to the legs! and everybody knows what quantities of water there are in the hot springs. And then there is the great display of the volcanoes, which come from a great deal of heat somewhere; and in places where volcanoes are extinct we can trace a sort of basaltic continent, so to speak, up to the very mouths of the craters from which the lava has come. So that there has been in all former ages undoubtedly much more heat than at present. There was another matter on which he would desire to speak, but with no great boldness, and that was the change in magnetism. The subject of terrestrial magnetism is one of the most obscure in the world; nevertheless, looking at the direction in which it always is towards the colder parts, and tracing its general phenomena, it may be effected by thermo-electricity, and that may be produced by the constant wear going on in the interior of the earth, where the fluid lavas are consolidating themselves. Within a few years the voyage of the *Challenger* has been made, and he had little hesitation in saying it was one of the most important in the scientific history of the world. In crossing the great seas they sounded to great depths, and measured in a satisfactory way the temperature of the water down to the depth of five miles. They always came to cold at the bottom; and there are great controversies whether the cold can come in deep sea streams from the frozen regions of the north. He thought that had some influence; but he thought the bottom of the water and the ground at those great depths is cold—he did not think that part of the earth partakes of the same heat as other parts; that he only expressed as his opinion, in which, of course, he might be met by the disbelief of a great many persons. That was the state of things as we know it regarding the temperature of the earth—that there is evidence everywhere that there has been enormous heat almost all over the earth. Some parts of the crust of the earth under the deepest seas are still perforated by volcanic islands. In some places the heat comes very near the surface. That he looked upon as an important fact, leading them to a theory of what the state of the earth really is.

On entering upon a matter which was undoubtedly one of the boldest speculations in modern science, which was the formation of the earth—he could not say its creation, but the way it got into its present shape—he had to premise that the theory on which he had to speak, which is known as the nebular hypothesis, is the conception of a very bold and vigorous intellect indeed. Laplace it was who remarked that all the planets and satellites revolved in the same direction round the sun, and all of them turned on their axis in the same direction: and it was difficult to deny that there must be some general cause for this. It naturally occurred to Laplace that if we can find something which is contracting its dimensions, and which has a little rotation to begin with, then with every contraction of dimensions that rotation would become more rapid, till it might go to any degree, depending upon the condensation of its various parts and its density before. Then can we come to look at any matter which is being thus condensed, and which might so form systems such as ours, with sun, planets, and satellites? There are a series of bodies in the sky which did not attract much attention in former days, mainly because telescopes were not so large, but which are now catalogued by thousands. These are the nebulæ. The name denotes their cloudy appearance. They are small bodies among the stars, sometimes appearing to have stars in them, or to be connected with stars, and sometimes not. They have the strangest and most capricious shapes imaginable. If this nebula is contracting its parts together so as to form a world, that rotation in the course of condensation will become so rapid that it may form suns and planets and earths around it; and on this supposition there is no difficulty in making a complete solar system out of such a mass as that of the nebula in Orion. Observations made lately by the largest telescopes—those of Lassell and Lord Rosse, both of which are remarkable telescopes of the largest class—have brought to light a number of nebulæ possessing a spiral appearance; and they seem to have some bearing on the supposition that the nebulæ are contracting and getting into a rotatory state. But these changes go on so slowly that they had not been able to answer with certainty for any of the changes of which he now spoke. The whole thing is theoretical, and yet, as it seemed to him, in the highest degree probable. Supposing this to be the case, these nebulæ would rotate, and in their compression would get very hot. There is no doubt that condensation would produce enormous heat, and it seems we have there sufficient explanation of the great heat we find below the surface of the earth and in other places. We suppose that the stars generally have been formed from the condensation of nebulæ; and there is a circumstance which was worthy mentioning. A series of observations founded upon optical experiments has come to light within late years which has done more to reveal the secrets of nature than anything before—this was by means of the spectroscope. By voltaic action sparks may be produced which derive their character—sparks like those of an electrical machine—in a great measure from the metals from which they spring. A spark springs from metal to metal, and the character of the metals gives different characters to the sparks. We have one set of these spectra produced by iron, another by nickel, others even by hydrogen gas, and so on, and these are observed and catalogued with great care. When we come to observe the light in the stars in the same manner, we find there are no two stars alike; some of them have the same spectra as that given from iron, and others have spectra from a number of different things; and we are actually able, by legitimate reasoning from this, to say from what the stars are made—what metals and other things they are made of, and, as a generat thing, there are no two stars alike. So that in this nebular hypothesis we are not bound to say that the nebulæ are all of the same materials, and we conceive that by comparing the bodies which we know in the solar system with those of the stars, we may arrive at an idea of the variety of materials of which the planets are composed. We cannot find anything different in comparing the light of the planets, because they all derive their light from the sun, and they do not present any difference of appearance in the spectrum. But we can draw conclusions from their relative density. As he had said to them, the average density of the earth is probably five and a half times that of water. They knew that the sun is only once that of water. What the sun is he could not tell, but it is a very poor light creature indeed. The density of Mercury is perhaps rather greater than that of the earth. The density of Venus is much the same as that of the earth, and the density of Mars is also much the same as that of the earth. Then after that comes a shower of little planets, about 200 of which have been observed up to the present time, and he could not tell what they are made of. Then there are Jupiter and Saturn, which are no heavier than water. So that it appears clear that, assuming the formation of these things by the condensation of nebulæ, on the theory he had mentioned, the different parts of the nebulæ which have contributed to the solar system are very different. Well, that being considered as established, it follows that in the constitution of our earth there may be parts of very different density. He should say that the high and prominent parts of the land are made of something light, and the heavy and dense parts are those covered by a considerable quantity of water, which have sunk deep into the central lava on which, he conceived, all things are resting.

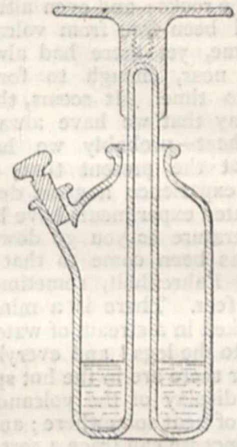
And now he had come pretty nearly to the end of his theory, and he would show them what he feared they would call an absurd representation of what he conceived the state of the earth to be. [The lecturer drew attention to a diagram of an "ideal earth," roughly showing his theory—some parts of the crust of the earth being thick and coloured darkly to indicate density; some thick and not so dense, and all admitting of volcanic eruptions from the interior, which was represented as lava.] Remember that everything here is exaggerated. It is not intended to be a correct representation. It is a caricature of the most extravagant kind; but if it conveyed to them the broad ideas that had impressed themselves upon his mind, it would be doing the right thing. He thought a large proportion of the centre of the earth is fluid and hot, and he thought that upon this there were certain divers classes of something like solid matter. In all these parts there are cracks or chinks through which volcanoes burst out where the cover of the earth is very thin. In some places you have two or three volcanoes together. There is one instance in Europe, where we have Etna, Stromboli, and Vesuvius. In this diagram he had condensed to the best of his conjectural power his supposition as to what the state of the earth really is; and if any one chose to find fault with it he would not quarrel with him. He only gave it as a sort of inference from a number of things he had said.

A NEW INSULATING STAND[1]

SIR WILLIAM THOMSON has frequently dwelt on the great importance of insulating, with the utmost care, any apparatus intended for researches relating to static electricity; he has shown that the atmosphere and other gases have but little effect in dissipating an electric charge, even when moist, and that it escapes mainly in consequence of the deposition of a layer of moisture upon the insulating supports which renders their surface conducting. In all Sir W. Thomson's electrometers there is an arrangement for drying the insulating surfaces by means of sulphuric acid, either free or absorbed by pumice. This method admits of very general application:—Any body, as for example apparatus constructed for the observation of atmospheric electricity, may be most perfectly insulated by supporting it on glass rods inserted in glass cylinders containing free sulphuric acid or pumice moistened with it. In order to do this the lower end of the rods must be either inserted into cylinders of lead or else fixed to the bottom of the jar by means of a substance not acted upon by sulphuric acid, for example, melted sulphur or paraffin; melted sulphur is liable, on account of its temperature, to crack the jars, notwithstanding the precaution of previous heating; paraffin, on the other hand, softens in the course of time, and the glass rods do not retain their vertical position. Notwithstanding these disadvantages excellent insulators may be thus extemporised as occasion may require.

[1] By M. E. Mascart, Professor of Physics, Collége de France, Paris.

For permanent use it is advantageous to employ insulators specially constructed, as shown in the accompanying figure; it consists of a bottle having a narrow neck,



through which passes a tubular continuation of the bottom, about 4 mm. less in diameter than the internal diameter of the neck, so as to leave a space of 2 mm. (about) between them. The top of this hollow rod is closed, in order that a brass tube may be cemented upon it, into which may be screwed any apparatus, as, for example, a disc as shown in the figure, a sphere, a crutch on a hoop, &c., &c. In the shoulder of the bottle is a neck, closed with a ground-glass stopper, through which sulphuric acid may be poured, in the first instance, and renewed from time to time. As the space between the hollow rod and the neck of the bottle is very small, the air in the bottle does not change very rapidly, and the sulphuric acid remains efficient for a long time. It is only necessary to run off a portion of it occasionally by means of a siphon, and to add fresh; as this may be done without disturbing the apparatus, the insulation may be maintained for any length of time. Moreover, for an insulator to be used occasionally, an addition is made of a vulcanised rubber cap, which slides on the glass rod to close the neck of the bottle when not in use.[1]

A double pendulum of pith balls supported by such an apparatus maintains its divergence, after being charged with electricity, for a very long time, even in a theatre filled with an audience. One may show by a simple experiment the great efficacy of this apparatus in comparison with insulators of glass exposed to the air, even when carefully varnished with shellac. If a pair of pith balls, suspended by a thread of cotton, is hung upon the latter support, and the metallic foot is placed on an insulator, and connected with a charged condenser, no divergence of the pith balls occurs in the first instance, but little by little the electricity is propagated along the glass rod, and then the threads near the support begin to separate, and soon after the balls diverge and remain at a certain distance from each other.

The electrometers of Sir Wm. Thomson are sometimes so perfectly insulated that the loss of a charge of electricity does not amount to $\frac{1}{100}$th part in twenty-four hours. By means of the insulator described above, one may obtain an insulation of like order for *bodies supported in the open air*, and thus diminish to a great extent one of the chief sources of error usually met with in experimenting with static electricity.

[1] These may be obtained of various sizes, one litre, half-litre, quarter-litre capacity, at Alvergniat Frères, 10, Rue de la Sorbonne, Paris.

RHEOSTATIC MACHINE

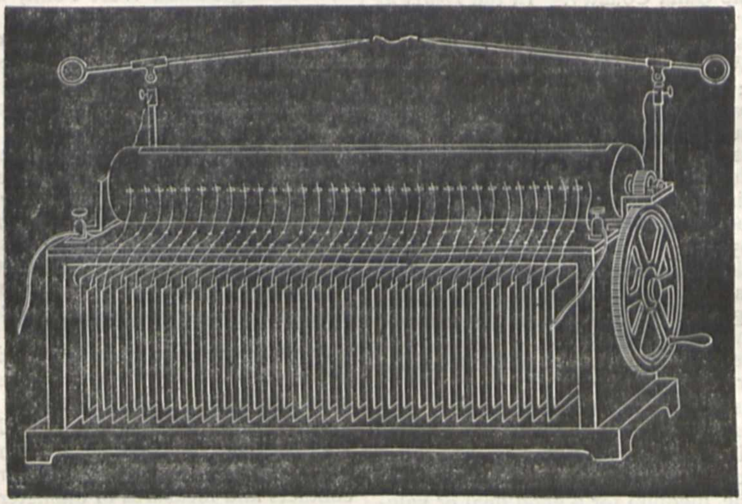
It is known that Franklin made use of a series of Leyden jars or fulminating plates, arranged in the form of a cascade, to obtain strong discharges of static electricity; that, on the other hand, Volta, Ritter, Cruikshank, &c., were able to charge condensers by means of the pile, and that these results gave rise to researches, conducted both by calculation and experiment, on the part of a great number of physicists.

I have been led to study, in my turn, the static effects of voltaic electricity, by means of a secondary battery of 800 couples which I at present possess; and I have devised an apparatus which shows the intensity that these effects may acquire.

After having proved how easy it is with this battery to charge rapidly an insulating plate condenser, sufficiently thin, of glass, mica, guttapercha, &c., I combined a certain number of condensers, formed by preference of mica covered with tinfoil, and arranged them as couples of the secondary battery itself, so as to be easily charged in *quantity*, and discha͏ged in *tension*.

All the pieces of the apparatus must be carefully insulated. The commutator is formed of a long cylinder of hard caoutchouc, provided with longitudinal metallic bands, intended to unite the condensers at the surface; and traversed at the same time by copper wires, bent at their extremities, for the purpose of uniting the condensers in tension. Small plates or metallic wires formed into springs are placed in connection with the two armatures of each condenser and fixed on an ebonite plate on each side of the cylinder, to which a rotatory movement can be given.

If we put the two sides of the apparatus into communication with the secondary battery of 800 couples, even several days after having charged it with two Bunsen elements, and if we set the commutator in rotation, we obtain, between the branches of the excitator, on which the armatures of the extreme condensers abut, a series of sparks entirely similar to those given by electric machines provided with condensers. By employing an apparatus of only thirty condensers, each of three square decimetres of surface, I have obtained sparks four centimetres in length.



The tension of a secondary battery of 800 couples is not necessary to produce marked effects with this apparatus. By putting in action only 200 couples, we have sparks of eight millimetres, and we may, without doubt, by diminishing still more the thickness of the insulating plates and multiplying the number of condensers, obtain effects with a source of electricity of less tension.

It is to be remarked that the discharges of static electricity, furnished by this apparatus, are not in directions alternately positive and negative, but always in the same direction, and that the loss of force resulting from the transformation must be less than in the induction apparatus; for, as the voltaic circuit is not closed a single instant on itself, there is no conversion of a part of the current into heat.

We may maintain the apparatus a long time in rotation and produce a considerable number of discharges without the secondary battery appearing sensibly weakened. This is because each discharge employs only a very small quantity of electricity, and because, as above stated, the circuit of the battery is not closed by a conducting body. The electricity of the source simply spreads over the polar surfaces presented by all the condensers, in proportion as they are discharged. This emission constantly repeated must nevertheless end by discharging a certain quantity of electricity; and when the instrument is charged by a secondary battery, we must ultimately exhaust, under the form of static effects, the limited quantity of electricity which the current of the battery can furnish.

Thus then, by another method than that of induction, properly so-called, by means of a simple effect of static influence renewed without cessation, we effect the transformation of dynamic electricity, so that this apparatus may be designated by the name of "rheostatic machine."

GASTON PLANTÉ

GEOGRAPHICAL NOTES

THE Berlin Geographical Society celebrated in characteristic German fashion the fiftieth anniversary of its foundation last week. Berlin, as our readers know, is not the only German city possessing a geographical society; indeed it has two. In Hamburg and Bremen are two excellent societies of this class, while the Continent, generally, is overrun with them. Russia has about a dozen, Belgium has at least two, Brussels and Antwerp, Holland one if not more, France at least half a dozen, Italy two or three, and the Scandinavian countries their own share. We do not consider it a disadvantage that in maritime countries there should be more than one geographical society, and we think it might be beneficial if even in our own country associations corresponding to the French societies of commercial geography were established in our chief ports, Liverpool, Glasgow, Bristol, Leith, Dundee. These might be branches of or affiliated to the London society, and might catch much that never reaches the latter. They might, moreover, do considerable service in encouraging the merchant service to obtain and bring home information that would be useful to science, and might, by means of lectures and otherwise, foster a scientific spirit among our commercial population. Much good is done in this way, we believe, by the societies of Marseilles, Bordeaux, and Lyons. Two new geographical societies have, we learn, been established in France, at Metz and Montpellier. The French are evidently doing their best to remove the reproach so frequently cast at them, of being more ignorant of geography than even the English.

THAT the Continental societies go in for earnest work is evident from the weighty journals published by most of them. The *Mittheilungen* of the Hamburg Society for 1876-77, for example, is a thick volume of 400 pages, containing a number of papers of considerable scientific value. Besides several papers on Central and South America, there is a long series of letters by Dr. Pfund, filling nearly half the volume, written during his travels in Kordofan and Darfur, along with Colonel Prout, of the Egyptian staff. Other African papers are by Dr. Paul Ascherson on his travels in the Lybian desert in 1876, and one of much value by Herr Fischer, on the present condition of the Galla Country. In the *Deutsche Geographische Blätter*, the organ of the Bremen Society, Dr. Oskar Lenz discusses at length the trade conditions in Equatorial West Africa, with special reference to Stanley's discoveries; Dr. Lenz does not believe that the Ogovai is connected with the Congo. Mr. W. H. Dall is contributing to this journal a series of papers on his own and other recent researches in the Aleutian Islands, while Dr. A. Ziegler has an interesting paper on Regiomontanus and Martin Behaim. Turning to Italy the energetic Roman Society has begun the publication (apart from their always interesting *Bolletino*) of *Memorie*, containing at length the most important papers read at the Society's meetings. The first part contains a lecture by the president, Signor Cristifero Negri, on scientific geography, which shows what has more than once been said, that geography is really the meeting-place of all the sciences. Then there is a paper on the geographical distribution of camels, by Prof. Luigi Lombardini, and a well-arranged series of instructions to explorers by various specialists, edited by Signor A. Issel. Nor must we forget the American Society, with its seat at New York, and which is the medium for a good deal of valuable information that might not otherwise reach the light of day. Chief-Justice Daly's presidential address always contains an admirable and exhaustive summary of the year's work; and this year it is quite as full and interesting as usual, nothing in the domain of geography of any importance remaining untouched, special prominence being of course given to the various surveys of the United States. Thus it will be seen, that under the name of geography, much varied and really valuable work is being done, and that dilletanteism has really but a small place in it, at least abroad.

AN expedition, comprising twenty-five miners and others, has started for New Guinea. This news is telegraphed from Sydney, and we earnestly hope that the expedition is under proper direction, both for the sake of the natives, who have so far been friendly to white men, and for the sake of further scientific discovery.

THE TRANSIT OF MERCURY

THE weather on Monday was so unfavourable that the observations of this interesting phenomenon were mostly unfortunate in England. In France some valuable observations seem to have been made. Our Paris Correspondent writes that the observations taken by M. Janssen at Meudon Observatory were wonderfully successful considering the state of the atmosphere. He was able to make use of spectrum analysis in order to determine the composition of Mercury's atmosphere. He was able to see Mercury before it had begun to make its first entrance on the disc. This observation is a confirmation of the phenomena observed in 1874 at Yokohama on the occasion of the Transit of Venus. Two photographs are excellent, and will lead to a determination of the diameter of the planet. At the Paris Observatory the transit was also seen.

When Capt. Mouchez saw Mercury the disc had been indented to the extent of 2″ of degree, about ⅓th diameter of Mercury. When it was seen by the brothers Henry it was half on the disc. The difference of time is about 10″ later at the National Observatory. The brothers Henry also saw the interior contact at about 3h. 23m. and some seconds. The exact time cannot be given yet. The contact was decidedly bad owing to the clouds.

At Algiers and Bordeaux the observations were bad. At Ogden, Utah, United States, the delegates sent by the French Government, M. André, of Lyons, and M. Angot, of Paris, obtained seventy-eight photographs of the transit. Satisfactory observations and photographs of the transit were taken at the Government Observatories at Washington and West Point, U.S.

Mr. J. J. Cole writes to the *Times* from Mayland, Sutton, Surrey, that the sun was clear from 3.5 to 3.25, and the whole ingress was steadily observed with a refractor of 6 inch aperture and three others smaller. The Greenwich mean times of external and internal contact were taken, and were confirmed by Mr. Bawtree near with unexpectedly small differences.

At Aberdeen the transit was observed by Lord Lindsay, Mr. Ranyard, Dr. Copeland, Mr. Carpenter, and Herr Lohse, and photographed by Mr. Davis. A thin cloud covered the sun at the time of first contact. No ring of of light was seen round the part of the planet off the sun's disc. External contact was observed spectroscopically by Lord Lindsay, who detected the approach of the planet by the eclipse of the C line thirteen seconds before its limb encroached upon the continuous spectrum of the photosphere. Mr. Ranyard observed the continuous spectrum below C line, but saw no trace of the planet until it was on the sun's disc. No change in the solar spectrum was observed at the limb of the planet. Dr. Copeland, Mr. Carpenter, and Herr Lohse obtained both contacts and measures of diameter.

Mr. C. G. Talmage writes as follows to the *Times* from Mr. Barclay's Observatory, Leyton, Essex:—

"Owing to the prevalence of clouds the times of external and internal contact at ingress were not observed here. The first view I obtained was at 3.43, when Mercury had advanced some considerable distance on the sun's disc. The duration of clear sky was then so short that there was not sufficient time to obtain micrometrical measures of distance from the sun's limb. For about eight or ten seconds the sky was absolutely clear, and then I noticed that Mercury was surrounded by a bright ring, darkening off to the periphery, which was exceedingly well defined. The distance between the limb of Mercury and periphery of ring was about two-thirds of the planet's diameter. I used the full aperture of ten inches, with a diagonal power of eighty."

DE CAILLETET'S APPARATUS

WE have already (vol. xvii. p. 265) spoken at length of M. Cailletet's method of liquefying the last of the gases, and at the same time we referred to the fact that students of science in France had not been forgotten by the accomplished experimenter. We described briefly a portion of an apparatus for use in laboratories for this experiment, and are now able to give an illustration of the complete laboratory apparatus as manufactured by Ducretet and Co., of Paris. The figure shows the apparatus one-eighth the size of reality.

To work this apparatus it is necessary to take off the liquefying tube T and all the pieces of the upper part; also the lateral screw E′ and its tube A′; then, after having screwed on to the joint R the piece N, which serves as a stop-valve, the mercury should be turned dry and quite pure, into the wrought-iron reservoir B, up to the level of the edges N N′. The sides of this iron reservoir are very resistant and are able to support strong pressures.

The tube T having been filled with gas for liquefaction, it is gently forced into the mercury of the reservoir B; the part N being taken out, the mercury which flows out is collected. When the tube A rests on the leather of the bottom of the length of the reservoir, the screw E′ is re-screwed very tightly. The apparatus is inclined a little to get rid of the excess of mercury, in order that its level may remain below the lateral hole by which the pressure is introduced.

The support S with refrigerating envelope M is then re-screwed on the upper part of the *ajutage* A; it rests

Au ¼ d'execution

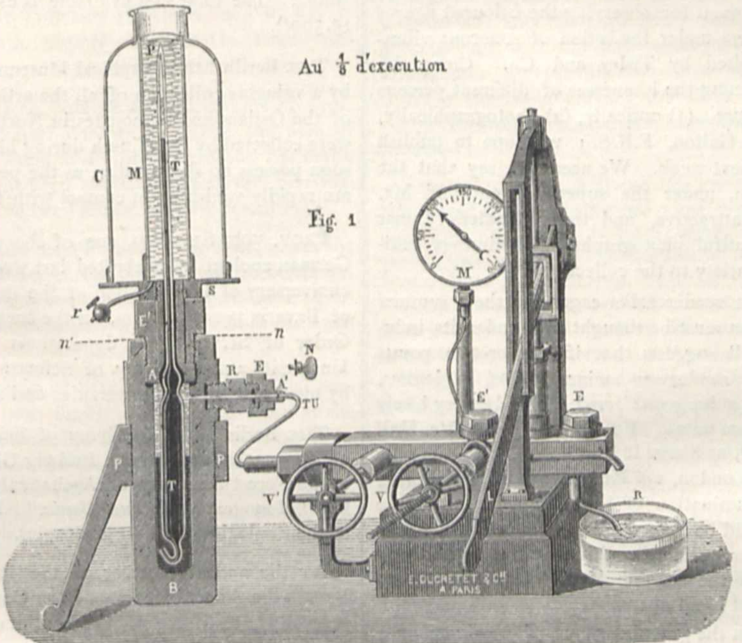
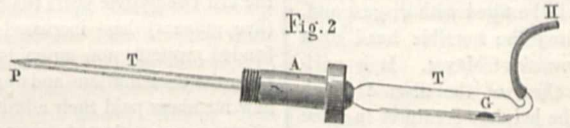


Fig. 1

Fig. 2



upon leather. The safety-bell-jar C is movable; it is intended to stop the pieces of glass should the tube T be broken. The stop-cock *r* lets the water flow from the envelope M. The lateral screw with the tube A′ is refixed, to which is soldered the small metallic tube T V, by which pressure is introduced.

The hydraulic pump, which Ducretet and Co. have constructed specially for this apparatus, is for the purpose of compressing water about the mercury contained in the reservoir. The two valves E E′ may be introduced by the orifices closed by the screws E E′; the valves may be thus tested and easily changed without undoing any part. The reservoir of water R is placed outside; it is then easily seen to and kept full.

Before setting the hydraulic pump to work, we withdraw as completely as possible the screw-plunger piston V by moving the fly-wheel. The action of the lever L enables us to obtain easily a pressure of 200 atmospheres. This pressure may then be increased by the gentle introduction of the plunger-piston V. The liquefying tube T is of thick glass; it has a resistance of about 400 atmospheres, but it is better not to exceed a pressure of 300 atmospheres. The second screw V′ is intended to produce expansion.

NOTES

ONE of the most effective methods of acquiring a headache is a good round of sightseeing, especially in a museum, collection, or picture-gallery; it is quite a comfort to get among a collection of any kind, the sight or catalogue of which does not make one ill by anticipation. Happily the headachy feature is generally absent from the collection of objects exhibited at the Royal Society *conversazioni*, and in this respect and because of its great interest, the collection brought together last Wednesday week was quite a model. Prof. Snellen's two modes of testing for colour-blindness ought to have been the first thing looked at, because then the guests would have been in a position to estimate the value of their observations. The inspection caused much amusement, and in some cases astonishment. The "Mechanical Chameleon," to exhibit the mixture of two colours in any proportion, was interesting, as was also Woodward's new rectangular prism illuminator, to be used with immersion lenses. The President's photographs of scenes and objects in the Rocky Mountains were specially attractive. Other objects which attracted considerable attention were—A large Holtz electric machine (by Ladd) consisting of twelve rotary and twelve stationary plates, thirty inches diameter, exhibited by Mr. W. Spottiswoode, Treas.R.S. A microspectroscope with improvements,—(1) quick movement of the slide carrying the slit; (2) scale for registering position of slit; (3) arrangement for comparing three spectra, and for splitting a single spectra; (4) new form of comparison stage, made by Mr. A. Hilger. A dynamo-electric machine, speed 800 revolutions, power 1·75 H.P. required to work it, effect 1,200 candles' light, exhibited by Messrs. Siemens Bros. The telephone harp, with visible records of sound through vacuum tubes, exhibited by Mr. F. A. Gower. Apparatus for showing figures in light from vibrations caused by sound, exhibited by Mr. Henry Edmunds. A metallic thermometer, invented by Mr. H. Bessemer; and apparatus for the automatic registration of the number of hours of sunlight, made for Kew Observatory, exhibited by Mr. J. Browning. A phoneidoscope, an instrument for observing the coloured figures reflected from liquid filters under the action of sonorous vibrations, made and exhibited by Tisley and Co. Composite portraits, made by combining the likenesses of different persons into a single resultant figure: (1) optically, (2) photographically, exhibited by Mr. Francis Galton, F.R.S.; we hope to publish a paper on the subject next week. We need not say that the phonograph in operation, under the superintendence of Mr. Preece, was specially attractive, and that Winkler's Lunar Landscape, and the beautiful photographs and paintings exhibited, lent a delightful variety to the collection.

THIS fine spring must render folks eager for their summer holidays, and many a plan must be thought over under its influence. Mr. Marshall Hall suggests that if one or two points and dates were fixed as rendezvous, mineralogists, geologists, botanists, entomologists, *et hoc genus omne*, might be very likely to accumulate and compare notes. For one such point Mr. Hall suggests the Hotel Bauer, at Sierre in the Valais, which can be reached in two day from London, *viâ* Paris, Pontarlier, Vallorbe, Lausanne, &c. For examination of the Lötchenthal and the Val d'Anniviers this would be a good place to start from, whilst travellers having mountain business could go about it north to the Oberland and south to the Pennine Alps. "If any other man knoweth a better place let him impart."

ANY ONE who has seen the graceful snout of a salmon or a trout, especially if he has looked upon it after an hour's exciting spin on a river or Highland loch, will be filled with disgust and, if an angler, with grief, on beholding the horrible head of a smolt figured in the *Gardeners' Chronicle* of May 4. It is positively loathsome. And this is the effect of the disease which has been proving so destructive to the helpless creatures in some of the Northern rivers, especially the Esk, Eden, Kent, and even the Tweed we believe. Mr. Worthington Smith has been making some inquiries into the nature of this disease which is killing not only salmon and trout, but eels, flounders, and other fish. He finds it to be a fungus (*Saprolegnia ferax*), which attacks mainly the head, tail, and fins. The scales appear to be covered with a fine white cottony bloom, which at length blinds the fish, envelops the gills, or even entirely closes the gills and mouth. Mr. Smith thinks the reason for the extraordinary abundance of the fungus this year is the unusual mildness of the winter. It seems only to attack the fish in fresh water, those in the estuaries escaping. We trust for the sake of our food supplies as well as on account of our genial friends the anglers, not to mention the poor fish themselves, that some means will be found of preventing the spread of the disease.

PROF. WIEDERSHEIM, of Freiberg University, writes us that through the kindness of Prof. Rutimeyer, he is in a position to describe a Labyrinthodont from the Trias, belonging to the palæontological collection at Basel. While hitherto nothing but the skull and some of the bony scales from the epidermis have been known, this specimen is completely preserved, whereby we obtain for the first time a full and clear insight into the organisation of the entire skeleton of this remarkable amphibian. But not only the skeleton with head, vertebral column, the shoulder and pelvis, down to the last phalanges of the fingers, are on view at the museum at Basel, but also a fine cast of the cranium and the spine, by which the extremely low organisation of the central nervous system of these animals is proved. Prof. Wiedersheim will publish a minute description of the remains in the Reports of the Swiss Palæontological Society.

AT the close of 1877 the amount subscribed for a statue to Linnæus was 44,276 Swedish crowns. This sum being insufficient, further contributions were obtained in Stockholm of 30,000 crowns, and the municipality of that city has undertaken to defray the expense of the pedestal and of the erection of the statue. The total sum available is estimated at 100,000 crowns (5,500*l*.).

THE Berlin Ethnographical Museum has lately been enriched by a valuable collection of all the articles used by the two tribes of the Ostiacs and Samojedes in North Siberia. These objects were collected by Dr. Finsch during his voyage in 1876, and will soon possess no slight value, as the peculiarities of these people are rapidly vanishing in contact with Russian civilisation.

PROF. VON SIEBOLD, one of the oldest and best known of German zoologists, celebrated last week in Munich the fiftieth anniversary of his reception of the doctor's degree. The King of Bavaria presented him, on the occasion, with the cross of the Order of St. Michael; deputations were sent by the Munich University and Academy of Sciences, and greetings were sent by numerous foreign universities and societies.

THE Berlin Royal Academy of Sciences has granted the sum of 400 marks (20*l*.) to Dr. Ludwig Graff, Professor of Zoology at the Forest-Academy of Aschaffenburg, for the completion of his "Monograph of *Turbellaria*." Dr. Graff is now at work at the Zoological Station of Naples.

AT the annual meeting of the Royal Institution of Great Britain the Annual Report of the Committee of Visitors for the year 1877, testifying to the continued prosperity and efficient management of the Institution was read and adopted. During the last twenty-five years the number of members paying annually (five guineas) has increased from 344 to 544. The real and funded property now amounts to above 84,500*l*., entirely derived from the contributions and donations of the members. Forty-one new members paid their admission fees in 1877. The principal officers were re-elected.

AT a special general meeting of the Birmingham Natural History and Microscopical Society, held on the 30th ult., Dr. Cobbold, F.R.S., was unanimously elected an honorary vice-president of the Society.

M. F. SOENSON has presented to the Swedish Academy the results of his experiments on the electric conductivity of solutions of various alums. These show that in all cases the conductivity increases directly with the concentration of the solution, and that while less intense than in solutions of the simple alkaline sulphates, it is always more intense than in solutions of aluminium sulphate. The green modification of chrome-alum possesses a greater conductivity than the red variety.

THE French Association for the Progress of Sciences is preparing for its next session, which will take place on August 28 at Paris. The Bureau has been completed and is composed as follows:—President, M. Fremy, Professor of Chemistry at the Polytechnic School and Museum of Natural History; Vice-president, M. Bardoux, the Minister of Public Instruction; Secretary, M. Perrier, of the staff, Director of the Ordnance Survey, Member of the Bureau des Longitudes and Council of the Observatory; Vice-secretary, M. Comte Saporta, Correspondent of the Institute; Treasurer, M. Masson, the scientific publisher; Secretary of the Council, M. Gariel, Engineer of Ponts et Chaussées. The session will take place at the École des Beaux Arts, a very extensive building containing many magnificent rooms for sections. For all inquiries relating to the Paris meeting letters must be directed to M. Gariel, Secretary of Council, 76, rue de Rennes, Paris.

AT the general monthly meeting of the Royal Institution of Great Britain, the Secretary announced that the managers had granted the use of the lecture-theatre to the Sanitary Institute of Great Britain for their anniversary meeting on July 3 at 3 o'clock, when an address would be given by Mr. Frank Buckland, M.A., on "The Pollution of Rivers, and its Effects upon the Fisheries and the Supply of Water to Towns and Villages."

MESSRS. BLACKWOOD have published a fifth edition of Prof. H. A. Nicholson's "Manual of Zoology." While the plan of the work is essentially the same as in former editions, the entire work, the author states, has been submitted to careful revision, and large portions of it have been almost entirely rewritten.

A COMMITTEE has already been formed in Holland, under the presidency of Prince Alexander of the Netherlands, to celebrate, in a fitting manner, the 300th anniversary of the eminent philosopher and statesman, Hugo de Groot, who was born on April 10, 1583.

A MEDALLION representing M. Thenard, the celebrated professor of chemistry, who was during a long time Dean of the Faculty of Sciences and Chancellor of the Paris University, has been sculptured on the walls of the Sorbonne courtyard. It was inaugurated on the occasion of the meeting of the Sociétés Savants. It bears the date of 1877, the centennial year of M. Thenard's nativity. M. Thenard died in 1857.

THE Jardin d'Acclimatation at Paris has just succeeded in obtaining an East Indian tapir, an animal rarely found in European collections, although the South American variety is comparatively common.

AN interesting work has just appeared in Stuttgart from the pen of Dr. R. Andree, on "Ethnographic Parallels and Comparisons." The author has chosen over twenty various subjects, and has gathered together on these topics an enormous amount of material from all the races on the globe. Among these subjects are constellations, cairns, measures of value, mothers-in-law, the vampyre, skull worship, the umbrella as mark of dignity, &c. In view of the rapid invasions of European culture in every direction, the author considers it of the utmost importance to complete as rapidly as possible the collection of all objects necessary to preserve a complete picture of the material and intellectual condition of the uncivilised peoples now existing.

MR. LUGGER, the curator of the Maryland Academy of Sciences, left Baltimore on April 4 for the purpose of prosecuting explorations in the West Indies and in Demerara in behalf of the Academy. In the course of his mission he will endeavour to procure living plants for the conservatory of Druid Hill Park and material for the zoological investigations of the Johns Hopkins University.

DESPITE numerous misfortunes, Berlin still continues to surpass all other European cities in its collection of anthropoid apes. The Zoological Gardens have just received from Borneo a healthy pair of orang-outangs, which, added to the one already in their possession, make an exhibition of rare interest.

ON the evening of April 23 Vesuvius showed signs of internal disturbance, sending up a column of flame at short intervals from the crater.

A FRENCH physician, Dr. Quimus, has lately made an elaborate study of a new disease, prevalent among telegraphic *employées*, and closely resembling writers' cramp. It is more common among the female operators.

FROM the last quarterly list of the members of the Institution of Civil Engineers, we gather that this increasing body now consists of 1,033 members, 1,759 associates, and 16 honorary members, together 2,808; besides a class of students attached numbering 520.

THE German Fischerei-Verein, of the activity of which we have made frequent mention, is engaged now in introducing the Californian salmon extensively into German waters. Of 300,000 eggs sent across the ocean, 25,000 arrived in good condition, and the resultant fish have been divided between the rivers of the Danube valley and those of the Rhine. 300,000 young eels from Normandy are being introduced into the Prussian streams.

AMONGST the few halls of the Paris Exhibition which can be considered as quite ready we must notice the excellent school exhibition of the City of Paris, which is situated in the central part of the palace.

A NEW remedy for diarrhœa in men and animals is said to have been discovered in New Zealand, where it has long been in use among the Maories. It consists in a decoction made by pouring boiling water on the green leaves of a shrub called roromiko by the natives. The liquid, though slightly bitter, is said to be not unpleasant to the taste. It is asserted that two doses of this decoction will always effect a cure even in bad cases.

A JAPANESE (native) paper states that a resident at Osaka has been endeavouring to manufacture oil from crude camphor, for which purpose he has built a large factory in that town. The oil he makes is described as being cheaper and better for purposes of illumination than kerosene.

ONE of the curiosities of industry, according to the *Japan Herald*, is the manufacture of boots by the Japanese for sale in the United States, a trade which is of quite recent origin, but has already attained considerable proportions. Oddly enough most of the leather used is imported into Japan from the United States.

A PRODUCT of the South Sea Islands, "copra" which is the dried kernel of the cocoa-nut, is being turned to a new account. Hitherto it has only been used for making oil, but now it has been discovered that the residue, after that process, is valuable as food for cattle and sheep.

THERE have been not a few signs recently that Spain is awakening from her long lethargy with regard to progress of all kinds, and one more comes to us in Nos. 6 to 25 (with the exception of No. 13, which has not come to hand), of the *Boletin de la Institucion Libre de Enseñanza* (Madrid), which make us acquainted with the Proceedings down to February 28. These recent numbers give us information as to the rules and objects of the Institution. By Article 1 the Institution is "Consagrada al cultivo y propagacion de la ciencia en sus diversos órdenes." By Art. 3 the number of Fellows is unlimited. By Art. 15 "La *Institucion* es completamente ajena á todo espiritu é interés de comunion religiosa, escuela filosófica ó partido político; proclamando tan solo el principio de la libertad é inviolabilidad de la ciencia y de la consiguiente independencia de su indagacion y exposicion respecto de cualquiera otra autoridad que la de la propria conciencia del Profesor, único responsable de sus doctrinas. Art. 16: La Institucion establecerá, segun lo permitan las circumstancias y los medios de que pueda disponer: 1. Estudios de cultura general (ó de segunda Enseñanza) y profesionales, con los efectos académicos que les concedan las leyes del Estado; 2.

Estudios superiores científicos; 3. Conferencias y cursos breves de carácter, ya científico, ya popular; 4. Una biblioteca y los Gabinetes dotados del material correspondiente; 5. Un boletin para publicar sus documentos oficiales y trabajos científicos; 6. Concursos y prémios, y cuanto contribuya á promover la cultura general y sus propios fines." These extracts from the statutes, ratified May 31, 1876, will sufficiently show the aims of the Institution, and show also what is being done for the cultivation of science in Madrid. Running through Nos. 10-15, 18-21, is a list of 728 shells, in the natural history cabinet, arranged on the method of Dr. Woodward's "Manual of Conchology," and in Nos. 22, 23 are catalogues of plants in herbaria from the Province of Avila and from the Philippine Islands. In Nos. 24, 25, a classification of rock specimens. The contents of the several numbers are of the same general character as we indicated in our former notice. The papers on Haeckel's morphology are continued, and the same professor (A. G. de Linares) has papers on the classification of geometrical figures, and on some recent publications on crystallography and mineralogy. The syllabuses are given of courses of lectures on two or three languages, on mathematics (arithmetic and synthetic geometry) and other subjects. We can only wish success to this the first (we believe) society, of the kind that has been formed in Spain.

No plant perhaps has a more varied adaptation than the bamboo. In every country where these gigantic grasses grow they are put to a multitude of uses. It is not then because the bamboo is incapable of being converted to any other use that so much attention has been given to it of late with the view of turning it into a source of supply for paper material. It is more on account of its rapid growth, the ease with which it can be propagated and its abundant yield, together with its wide geographical range, that such interest has been roused in it, for the several species of bamboo are found in most tropical parts of the world. If, however, it should become a regularly recognised paper material there is no doubt that our supplies would be obtained chiefly from the East and West Indies. With regard to its growth in the latter country there seems to be a prospect that it may prove successful for cultivation in plantations specially formed for growing the plants for paper stock. There are, of course, extensive natural resources of bamboo, but it is thought that by cultivation and a system of irrigation the yield would be greatly increased and the cost of keeping up such a plantation would, after the first two years, be almost *nil*. It is by no means improbable that the bamboo will in the course of time become an important paper-making commodity.

A STRANGE meteorological phenomenon was recently observed at Logelbach, in Upper Alsatia. The rising sun seemed to be surrounded by a vast column of fire. An eye-witness describes the occurrence in *La Nature*. When he began his observations, the column had already reached a height of 25 or 28 degrees. Its breadth remained constant, and amounted to 2 or 2½ degrees. Its colour was greyish red, and at its upper end orange; the dull and cloudy sky formed a fine contrast with the brilliant phenomenon. From 6.30 A.M. till 7 o'clock its brilliancy remained much the same, while its extent towards the west increased by about 4 or 5 degrees. At 7 o'clock the sun's disc appeared above the horizon, and its tint was an intense red. The whole sky now seemed to be a gigantic rainbow, all the shades of which appeared in horizontal layers, forming a splendid background to the bright red and orange vertical column. A minute later the sun lost its red tint and the column gradually decreased; for five minutes it formed a band of 5 degrees in height, and then disappeared altogether.

DECADE V. of the "Prodromus of the Palæontology of Victoria," by Mr. Frederick McCoy, of the Geological Survey of Victoria, deals, by means of well-executed lithographic illustrations and text, with numerous fossils of the tertiary and Upper and Lower Silurian formations.

THE recent numbers (26-31) of Bentley and Trimen's "Medicinal Plants" fully maintain the excellence of the earlier ones. Among the admirable plates of well-known plants in these numbers may be mentioned those of *Aconitum ferox*; the opium-poppy, *Papaver somniferum*; the liquorice, *Glycyrrhiza glabra*; the indigo, *Indigofera tinctoria*; the camphor, *Cinnamonum camphora*; and the sabine, *Juniperus sabina*. The only one in these numbers which does not strike us as so happy, is that of the common marjoram, *Origanum vulgare*.

WE regret that the name of M. Milne-Edwards somehow got among the catalogue of the eminent men whom we named last week as having gone over to the majority during the existence of NATURE. We are glad to say that M. Milne-Edwards, though as old as the century, is as active as ever.

THE addition to the Zoological Society's Gardens during the past week include a Lion (*Felis leo*) from Africa, presented by Mr. J. D. Massey; a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mr. G. W. Twining; a Macacque Monkey (*Macacus cynomologus*) from India, presented by Mr. J. M. Neil; a Black-eared Marmoset (*Hapale penicillata*) from South-East Brazil, presented by Mr. Walter M. St. Aubyn; a Common Cormorant (*Phalacrocorax carbo*), European, presented by Lord Braybrooke; four Green Lizards (*Lacerta viridis*) from the Isle of Jersey, presented by Mr. F. E. Lawder; a Black Ape (*Cynopithecus niger*) from the Celebes, a Brazilian Tree Porcupine (*Sphingurus prehensilis*) from South America, deposited; two Lesser Birds of Paradise (*Paradisea papuana*) from New Guinea, two Black Storks (*Ciconia niger*) European, purchased; two Black-faced Spider Monkeys (*Ateles ater*) from East Peru; a Common Cassowary (*Casuarius galeatus*) from Ceram, a Golden-winged Woodpecker (*Colaptes auratus*) from North America, received in exchange; a Great Kangaroo (*Macropus giganteus*), an Eland (*Oreas canna*) born in the Gardens.

ACADEMIC LIBERTY IN GERMAN UNIVERSITIES[1]

IN taking possession of the high functions to which the vote of my colleagues has raised me, my first duty is to renew here, publicly, the expression of my thanks towards those who have given me this proof of their confidence. Its value is all the greater in my eyes because it has been given to me notwithstanding the few years I have passed among you and notwithstanding my function of professor in the natural sciences which form, in the curriculum of university education, a foreign element, the introduction of which has caused the modification of several points in the ancient organisation of the faculties, and will yet induce others in the future. The department of physics to which I have devoted myself is exactly that which contains the theoretical foundations of all the other branches of the natural sciences, and which presents in the most striking form the characteristic features of their methods. Thus I have several times already been compelled to propose to the University modifications in the rules previously followed, and I have had the pleasure of being always backed by the hearty support of my colleagues and the University Senate. Since you have chosen me to direct the University during the course of the next year, it is a proof, in my eyes, that you do not regard me as a rash innovator.

The object, the method, the immediate aim of the natural sciences may at first sight appear altogether distinct from those of the moral sciences; it seems to men accustomed to occupy themselves exclusively with the immediate expression and the proofs of the intellectual life, that they have nothing to learn from the results of these sciences, and that they have for them only a remote interest. But, in reality, as I have already

[1] Rectorial Address of Prof. Helmholtz, F.R.S., at the University o Berlin.

endeavoured to show in my rectorial address at Heidelberg, there is a very close relationship between the two orders of sciences; they pursue the same final end by processes which, at bottom, are the same. If the greater part of the researches in the natural sciences have not for their immediate object an intellectual advantage, on the other hand, it should not be forgotten, that the power of the pure intellectual method is here shown much more clearly, and a penetrating analysis of phenomena makes known the true and the false with much more precision than can be the case in the complex problems of the moral sciences.

Side by side with the development of this new branch of scientific activity, almost unknown in antiquity, the changes which have supervened in political, social, and even international relations, also exercise an influence which must be taken account of. The circle of our students is enlarged; the transformation of public life entails new exigencies; the various branches of science are more and more subdivided; it becomes necessary to add to libraries other means of study more and more considerable and more and more varied. It is difficult to foresee what new wants and what new exigencies we shall have to face in the near future.

On the other hand, it is not only in our own country that the German universities have a place of honour: they attract the attention of the civilised world. Students speaking the most diverse languages flock to them from the ends of the earth. A false step may make us fall from this high position, and it would afterwards be difficult to regain it.

In these circumstances it is our duty to seek to discern clearly what has hitherto been the internal principle of the prosperity of our universities, what essential element of their organisation must be maintained intact as a thing sacred and inviolable, and in what direction our efforts should tend when reforms become necessary. I do not consider myself authorised to pronounce on these questions in a definitive manner. The point of view of each of us is necessarily a little exclusive; the representatives of other sciences may, from other points of view, advance different considerations. But I think that, in order to arrive at definite and fixed conclusions, it is necessary that each one seek to express exactly what are his particular ideas on these questions.

Over all Europe, in the Middle Ages, the universities had their origin in unions, free and private, of students grouped under the influence of celebrated masters. These unions regulated their own affairs. In recognition of the public services they rendered, the Governments soon accorded them guarantees, privileges, and honours, notably the right of examining their members and of conferring academic degrees. The students of that epoch were, for the most part, mature men, who resorted to the universities for the purpose of being instructed and without any immediate practical end. Soon they commenced to send young men also, placed very often under the care of older students. Each university was divided into more restricted associations, known under the names of Nations, Bourses, Colleges. The older graduate members of these associations, the *Seniores*, administered the special affairs in each of them, and met in general assembly to discuss the affairs common to all the university. We may see even to-day in the court of the University of Bologna the list and the arms of the members and *Seniores* of the various Nations which formerly composed it. The oldest graduates were regarded during their whole life as members of the association; they preserved their right of voting, a custom which has been continued almost to our own days, or which exists still in the college of the doctors of the University of Vienna and in the colleges of Oxford and Cambridge.

Thus, a free union of independent men, all brought together, masters and pupils, by the pure love of knowledge, the one anxious to know the treasures of intellectual culture left by antiquity, the other labouring to communicate to the new generation the enthusiasm for the ideal which had kindled their souls; such was the origin of the universities, whose organisation, in its principles and its details, was founded on the most complete liberty. We must not, however, believe that they admitted the liberty of education in the modern sense of the term. The majority showed itself very intolerant to differences of opinion. More than once those who found themselves in the minority were compelled to quit the university. This occurred not only when the Church intervened or when political or metaphysical questions were agitated. The faculties of medicine themselves, and at their head that of Paris, the most celebrated of all, would not tolerate any deviation from what they regarded as the doctrine of Hippocrates. They expelled from their midst those who practised the medicine of the Arabs or who admitted the circulation of the blood.

The transformation which led the universities to their present situation was due principally to the action of the State, which provided them with material assistance, and, in exchange, assumed the right of interfering in their affairs. The progress of this development was not the same in the various countries of Europe; it was determined in part by the political situation, in part by the peculiar character of each nation.

Those which underwent the fewest changes were the two old English universities of Oxford and Cambridge. Their large revenues and the political tendency of the English to respect all acquired rights have preserved them almost absolutely from alteration, even on points where changes would have been extremely desirable. These two universities preserve even to-day the character of schools intended to recruit the clergy, formerly the Roman Catholic clergy, now that of the Anglican church. The laity participate in the education which is there given, in so far as that may contribute to general intellectual culture; but they must submit to the discipline and the mode of life which were formerly considered suitable for yoang clerics. They live together in kinds of colleges, under the surveillance of a certain number of elder graduates (Tutors) belonging to the same college; for the rest they follow the manners and customs of the wealthy classes of England. They can only go about in a certain costume, of a somewhat ecclesiastical cut, with special *insignia*, indicating not only their academic grades, but also their social rank. The education, in its basis and method, is that of our gymnasia, but a little more developed; in certain points only it approaches more the *repetitions* organised in our universities; thus, it is limited to the programme required for examination, and the students are bound to study certain books, indicated beforehand. The work of the students is controlled by very detailed examinations, which must be passed in order to obtain the academic degrees, and in which very special knowledge is required, but only in certain very narrow subjects. All the old degrees of the academic dignities, the baccalaureate, the licentiate, the mastership in Arts, the doctorate, are obtained by tests of the same kind. The lessons are generally given by the Tutors above referred to. But they do not teach by virtue of an official delegation like the masters in our gymnasia; there are rather special masters chosen by certain groups of students. There are few professors, and they give only a small number of lectures to a scanty auditory, and usually on a very special subject. These lectures do not constitute an essential part of the education; they serve at the most to furnish to some students, having a special interest to make great efforts, the occasion for more profound study. The various colleges are, moreover, completely separated from each other; the examinations, the conferment of degrees, the nomination of professors are the only matters common to the whole university.

It is only quite recently that students not belonging to the Church of England have been admitted, and that some little attempt has been made to provide for professional education in law and medicine. Among the professors of the English universities, there is a great number of very distinguished men, and who have a place in science. But the right of taking part in their election is not reserved to the Fellows actually forming a part of the corporation; it belongs equally to all the former Fellows, even when they have no longer any connection with the university, when they have no interests in common with it, and when they may be engaged in the struggles of political and ecclesiastical parties. The result is that party considerations, personal connections, and friendship, often exercise more influence on the elections than scientific merit. From this point of view the English universities have preserved all the intolerance of the middle ages. The professors are not required to reside in the university town; they may fix their abode in any part of the kingdom; they may even fill other functions at their convenience, often, for example, that of parish priest; it is enough that they give their lesson at the university once a week, sometimes even more seldom.

The English universities devote a very small portion of their enormous revenues to the endowment of chairs and to filling them with masters having an indisputable authority in science, and this little is badly employed. But they possess another institution which appears called upon to render the greatest service to scientific studies, although hitherto it has done very little in this respect; this is the institution of Fellowships. The students who have passed highest in the examinations are authorised to remain in the quality of Fellows in their college, where they are lodged and boarded; they receive, besides, a pension of 200*l*., which assures to them the liberty of devoting all their time to science. Oxford has 557 places of this kind, Cambridge 531. The Fellows may act as tutors to the students, but they are free not to use this privilege. They are not, moreover, obliged to live in the university town; they may spend their pension where they please, and preserve it during an indefinite period. Save in exceptional cases, they only lose it when they marry, or when they accept some employment. They are the legal successors of the old student corporations, by and for whom the universities were founded and endowed. But beautiful as the plan of the institution may be, fabulous as may be the sums devoted to it, the services which it renders to science are of the most mediocre in the judgment of all unprejudiced Englishmen. This is probably owing to the fact that these young persons, although they are the *élite* of the students, and find themselves in conditions exceptionally favourable to work, have not been, during the course of their studies, sufficiently profoundly penetrated by the vivifying spirit of science, to experience that enthusiasm and that passion which impels men to make personal efforts.

The English universities render, from certain points of view, very important services. They make their students cultured men, although little disposed to pass the political or religious limits of their party, and, in fact, they do not go beyond these; the Tories dominate at Oxford, the Whigs at Cambridge. We ought, above all, to seek to rival them in two things. In the first place, they develop in a very high degree among their students, at the same time a lively sense of the beauties and the youthful freshness of antiquity, a taste for precision and elegance of language; this is seen in the fashion in which the students manage their mother tongue. There is here, I fear, one of the weakest sides in the education of youth in Germany. In the second place, the English universities pay much more attention than ours to the physical well-being of their students. These live and work in spacious, well-aired buildings, surrounded with lawns and with masses of trees; their pleasures consist specially in games which, exciting a passionate emulation, favour the development of the vigour and dexterity of the body much more efficaciously than our military and gymnastic exercises. It must not be forgotten that if we deprive young people of the open air and of the opportunity of developing their vigour, they are all the more led to seek unhealthy distractions in the abuse of tobacco and strong drinks. We must admit, besides, that the English universities accustom their students to serious and energetic work, and make them preserve the habits of well-bred people. As to the *moral* effect of a rigid surveillance, it must be tolerably illusory.

The Scotch universities, and some small English universities of recent formation, as University College and King's College, London, and Owens College, Manchester, approach more to the German and Dutch type.

The French universities have followed a different, almost absolutely opposite course. In consequence of the tendency of the French to upset, in virtue of logical theories, all which is the product of a historical development, their faculties have become simple establishments of instruction, special schools preparing for a career, and in which the programme of education is subjected to fixed rules. They are completely distinct from the institutions devoted to the progress of science, such as the Collége de France, the Jardin des Plantes, l'Ecole des Hautes Etudes. The faculties are absolutely separate from each other, even when they are placed in the same town. The course of study is determined with precision; numerous examinations serve to control the results. French education is limited to what is clearly and solidly established; it gives an exposition of this, well ordered, carefully elaborated, easily intelligible, without entering upon doubtful questions and without going to the bottom of things. The masters charged with distributing it only need to have acquired much. Thus, in France, it is almost a mistake on the part of a young man possessing a talent full of promise, to consent to become professor in a provincial faculty. The French system is well suited to give to students of moderate capacity knowledge sufficient to follow the routine of their profession. They have not to choose between different professors, and, consequently, they swear *in verba magistri;* there results a propensity to doubt nothing and to be self-satisfied. If the professor is good, that suffices for ordinary cases, where the student has only to imitate what he has seen his master do. It is only in extraordinary cases that it may be seen if he has really acquired penetration and judgment. For the rest, the French nation is well endowed, lively and ambitious; this makes up for many of the faults of the system of education.

In the French universities—and it is a characteristic feature of their organisation—the situation of a professor is absolutely independent of the assent of his pupils. The students belonging to the faculty in which he is professor are bound to follow his lessons; the very high fees which are paid go to the treasury of the Minister of Public Instruction, and serve to cover the fixed salary of the body of professors; the State contributes to the expenses of the universities only to a very small extent. If, then, the professor has not really the passion for education, and if he has not the ambition of attracting a large auditory, he may remain indifferent to the success of his instruction and take it easy. Outside the lecture-rooms, where they take their courses, French students live without being subjected to any surveillance, without *esprit de corps*, and without particular habits, confounded with young people of the same age who follow other careers.

The development of the German universities has followed a course intermediate between these two opposite paths. They were too poor in private resources not to accept eagerly the help of the State in presence of the more and more costly demands of education. Consequently at the epoch when modern states tended to consolidation they were not in a position to defend their ancient privileges, and they had to submit to the directing influence of the State. Consequently for all the important affairs of the universities, the supreme decision was, in principle, reserved by the State, and in times of political and religious disturbance an inconsiderate use was often made of this supremacy. In most cases, however, the universities were favourably treated by the governments newly arrived at independence. They required intelligent functionaries, and the glory of their university threw upon them a certain *éclat*. The administrative functionary came, for the most part, from the universities and remained attached to them. Thus, in the midst of the tumult of war and of political convulsions, in all these states struggling with the tottering empire and occupied in consolidating their recent independence, while nearly all other special privileges disappeared, the German universities succeeded in retaining a much more considerable part of internal liberty (and indeed the most precious elements of this liberty) than was the case in conservative England and in that France which is feverishly chasing after liberty.

Among us the old conception of the student remains the same; he is always considered as a responsible young man who pursues science of his own accord, and who is free to regulate as he pleases the plan of his studies. If, for a small number of careers, it is still necessary to follow certain courses, this obligation is not imposed by the university as a university, but by the authority which will at a later period admit the candidate to follow these careers. Moreover, students have to-day, and had formerly, with few exceptions, full liberty to choose among all the universities of the German tongue, from Dorpat to Zurich, Vienna, and Graz. They may choose, besides, in each faculty, among the masters who teach the same subjects, without taking account of the distinction between ordinary professors, extraordinary professors, and privat-docenten. It is even allowable for them to obtain their instruction from books to any extent they may desire; it is, in fact, very desirable that the works of the great men of the past should constitute an essential part of study.

Outside the universities no surveillance is exercised over the conduct of the students, provided they do not come into collision with the agents of public security. Except in this case, the only control to which they are subject is that of their comrades, which prevents them from doing anything against the honour of the body. The universities of the Middle Ages were close corporations, exercising over their members a jurisdiction which was extended to the right of life and death. As the students found themselves for the most part on foreign soil, this special jurisdiction was necessary, not only to withdraw them from the judgment of the authorities of the country, but also to be able to allay the conflicts which arose among themselves, and to maintain in the corporation sufficient good order and good breeding to insure the maintenance of the hospitality offered. Under the influence of the modern political organisation, this academic jurisdiction has gradually given way before the ordinary jurisdiction; the last vestiges will soon disappear, but the necessity always subsists in such numerous meetings of lively and eager youths, of submitting to certain restrictions calculated to preserve the tranquillity of their comrades and that of the citizens. It is to this necessity that, in cases of conflict, the disciplinary jurisdiction of the University authorities responds. However, this end is still more surely attained by the sentiment of the honour of the body, and it is gratifying to have to acknowledge that this consciousness of their moral solidarity, and of the obligations of honour in the case of every one resulting therefrom, remains alive among German students. I do not mean by this to approve of all the special prescriptions of the code of honour of students. There are among the number certain remains of the middle ages of which it would be good to get rid, but this is a thing which can only be done by the students themselves.

(*To be continued.*)

STRIDULATING CRUSTACEANS

AT the November meeting of the Entomological Society of London, the president, Prof. Westwood, directed the attention of the Society to a letter in NATURE (vol. xvii. p. 11) from Mr. Saville Kent, on the above subject, *à propos* of Mr. Wood-Mason's recent discovery of the existence of stridulating apparatus in scorpions.

Mr. Wood-Mason remarked that structures in Crustacea, some of which certainly, and all of which probably, are for the production of sounds, were first brought to notice by Hilgendorf—in V. der Decken's "Reisen in Ost-Africa (Crustacea)"—but had been independently observed by himself in a number of species during his dredging excursion to the Andaman Islands in 1872. They were paired organs, as in scorpions, the *Mygale*, and the *Phasma* to be brought to notice that night—that is to say, organs working perfectly independently of each other were on each side of the body. In some forms (I.) they were seated partly on the body (carapace) and partly on a pair of appendages; of these some (*a*) had the *scraper* on the body and the *rasp* on the appendages—*e.g. Matuta*, in which the organs are developed in both sexes; and others (*b*) had the *rasp* on the body and the *scraper* on the appendages—*e.g. Macrophthalmus et affinia*, in which the scraper was formed by a sharp-edged lamellar projection on the meropodite of each of the chelipeds, and the rasp was the crenulated infraorbital margin; in these the apparatus could only be developed in the males, the females having short and small and quite inconspicuous chelipeds, which hardly reached so far as to the margins of the orbits. In others (II.) they were seated wholly on the appendages; in the males of the species of *Ocypode* the *rasp* was on one and the *scraper* on another part of the same appendage; in those of *Platyonychus bipustulosus* the *rasps* were on one and the *scrapers* on another pair of appendages; the walking-legs of the second pair were here very long and robust, and their third joint (meropodite) had its upper margin produced upwards at apex into a sharp crest (the *scraper*); both Dana and Milne-Edwards had noticed the remarkable length and structure of this pair of legs, but the former alone had mentioned, in his description of the species, the regular transverse plication of the under surface of the propodite of the chelipeds, which constituted without doubt the *rasp*. The above did not pretend to be a complete account of stridulating apparatus in Crustacea; but separated as he at present was from notes, drawings, and specimens, he could not go into greater detail. The cases of *Macrophthalmus* and of *Platyonychus* had not, he believed, been previously recorded. In the forms alluded to by Mr. Kent, no special sound-producing apparatus seemed to be developed. Everybody who had searched for animals on coral-reefs or had dredged in tropical seas was familiar with the "clicking" sounds emitted by the *Alphei* and their allies. The sounds which here always accompanied so sudden an opening of their claws to their fullest extent that dislocation seemed imminent each time, might be caused either by the impact of the dactylopodite upon the joint to which it is articulated, or by the forcible withdrawal of the huge stopper-like tooth of the dactylopodite from its pit in the immovable arm of the claw; in which latter case the noises might be susceptible, *mutatis mutandis*, of the same physical explanation as that produced by the withdrawal of a tightly-packed piston from a cylinder closed at one end. These were the explanations that occurred to him while watching a small species that lived in force amidst the branches of the zoophytes called *Spongodes*, the masses of which crackled all over when brought to the surface. The sounds in this case resembled very closely those made when sparks were taken by the knuckles from the prime-conductor of a small electrical machine. The sounds emitted by the Sphæromid might possibly be produced by the impact of the terga of the posterior somites upon one another at the end of each movement of extension.

Mr. Wood-Mason then announced the discovery of stridulating organs in *Phasmidæ*, in a species of *Pterinoxylus*, and in illustration of his remarks exhibited an impression of Westwood's plate of Serville's species, *P. difformipes*. Here, as in Crustacea and some other Arthropods, an apparatus working perfectly independently of its fellow was developed on each side of the body. The rough prominent basal portion of the costal nervure of the wings formed the rasp, in connection with which was developed a large oval "speculum," "talc-like spot," or "mirror." The rasps were scraped by the sharp and hard front edges of the tegmina, the dome-like form of which seemed admirably adapted, and probably did, to some extent, serve to increase the sound by resonance. In Serville's species, according to Westwood's figure, the stridulating apparatus appeared to be more highly developed, the "mirror" being more distinct, and the tegminal cavities more spacious. The males of the *Pterinoxyli* were unknown. We had here another case in which functional stridulating organs are present in females. The only other insects known to him in which stridulating organs were seated partly on the wings and partly on the tegmina were the orthopterous *Œdipoda*, which, according to Scudder (*Amer. Nat.* ii. 113), stridulate during flight, in connection with which fact it was interesting to observe that the female *Pterinoxyli*, though incapable of flight, needed to expand their organs of flight in order to bring their similarly situated apparatus into play.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—At Queen's College, James Henry Hickens, Epsom College, has been elected to a Natural Science Scholarship.

CAMBRIDGE.—The Rede Lecture will be delivered by Prof. Clerk-Maxwell, in the Senate House, on Friday, May 24, at half-past 2 o'clock, on the Telephone.

OWENS COLLEGE.—Should this institution ever be transformed into the University of Manchester, it will only be after overcoming a good deal of strong opposition. The Liverpool Town Council are to petition in favour of a new corporation with power to incorporate Owens College and other institutions, and that the new University do not bear any merely local or personal appellation. Naturally, also, the Yorkshire College does not look kindly on the proposal, although until Owens College resolved to take this step the two institutions were on very friendly terms. We trust some arrangement will be come to ultimately that will satisfy all concerned.

WORKING MEN'S COLLEGE.—The Science Classes at the Working Men's College, which, during the last three years have, under Mr. Dunman's teaching, have become so popular and useful a feature of that institution, assembled on Saturday last at the Broad Street Restaurant to celebrate the termination of a very successful course by a dinner. Mr. Thomas Hughes had promised to be present, but in his compulsory absence Mr. Dunman himself occupied the chair. A pleasing feature of the evening was the presentation to Mr. Dunman, by the students in these classes, of a handsome despatch box as a token of their appreciation of the thoroughly efficient manner in which he has discharged the duties of science teacher.

STRASSBURG.—The Extraordinary Professorship of Petrography, lately occupied by Prof. Rosenbusch, is to be filled by Dr. Cohen, of Heidelberg.

SCIENTIFIC SERIALS

THE *Journal of the Russian Chemical and Physical Societies* of St. Petersburg (vol. x. No. 3) contains the following papers:—On the mono- and dioxymalonic acids (Part 2), by R. Petrieff.—Researches on the transformation of diethylcarbinol into methylpropylcarbinol, and on the synthesis and the properties of diethylacetic and methylpropylacetic acids, by A. Saytzeff.—On the synthesis of diphenylenephenylmethane and of diphenylenetolylmethane, by V. Hemilian.—On the falsification of butter, by P. Koulechoff.—On the elementary law governing the reciprocal actions between currents and magnets, by A. Socoloff.

Verhandlungen der k.k. Zoologische botanischen Gesellschaft in Wien. (1867, vol. ii.) This volume, like its predecessors, contains valuable additions to zoological and botanical literature. By far the most important papers contained in it are Dr. L. Koch's notes on Japanese *Arachnida* and *Myriapoda*, and Herr H. B. Möschler's remarks on the *Lepidoptera* fauna of Surinam, continued from a former volume. Of other interesting papers we note:—Lichenological excursions in the Tyrol, by F. Arnold.—On the spiders of Uruguay and other parts of America, by E. Keyserling.—Introduction to the monography of *Phaneropterida*, by Brunner von Wattenwyl.—Hymenopterological notes, by F. F. Kohl.—On the flora of the Ionian Islands of Corfu, Cephalonia and Ithaca, by G. C. Spreitzenhofer.—On a species of *Aphis, Pemphigus Zeae Maïdis*, L. Duf, which attacks Indian corn, by Dr. Franz Löw.—Notes on the *Aeolidiadae*, by Dr. Rudolph Bergh.—On the Brazilian ants collected by Prof. Trail, by Dr. Gustav Mayr.—There are also in this volume some smaller communications from the botanical laboratory of Dr. H. W. Reichardt.

SOCIETIES AND ACADEMIES

London

Royal Society, April 11.—"On Stresses in Rarefied Gases arising from Inequalities of Temperature," by J. Clerk-Maxwell, F.R.S., Professor of Experimental Physics in the University of Cambridge.

1. In this paper I have followed the method given in my paper "On the Dynamical Theory of Gases" (*Phil. Trans.* 1867, p. 49). I have shown that when inequalities of temperature exist in a gas, the pressure at a given point is not the same in all directions, and that the difference between the maximum and the minimum pressure at a point may be of considerable magnitude when the density of the gas is small enough, and when the inequalities of temperature are produced by small solid bodies at a higher or lower temperature than the vessel containing the gas.

2. The nature of this stress may be thus defined; let the distance from the given point, measured in a given direction, be denoted by h, and the absolute temperature by θ; then the space-variation of the temperature for a point moving along this line will be denoted by $\frac{d\theta}{dh}$, and the space-variation of this quantity along the same line by $\frac{d^2\theta}{dh^2}$. There is in general a particular direction of the line h, for which $\frac{d^2\theta}{dh^2}$ is a maximum, another for which it is a minimum, and a third for which it is a maximum-minimum. These three directions are at right angles to each other, and are the axes of principal stress at the given point; and the part of the stress arising from inequalities of temperature is in each of these principal axes a pressure equal to—

$$3\frac{\mu^2}{\rho\theta}\ \frac{d^2\theta}{dh^2},$$

where μ is the coefficient of viscosity, ρ the density, and θ the absolute temperature.

3. Now, for dry air at 15° C., $\mu = 1{\cdot}9 \times 10^{-4}$ in centimetre-gramme-second measure, and $\frac{3\mu^2}{\rho\theta} = \frac{1}{p}\,0{\cdot}315$, where p is the pressure, the unit of pressure being one dyne per square centimetre, or nearly one-millionth part of an atmosphere.

If a sphere of one centimetre in diameter is T degrees centigrade hotter than the air at a distance from it, then, when the flow of heat has become steady, the temperature at a distance of r centimetres will be

$$\theta = T_0 + \frac{T}{2r}, \text{ and } \frac{d^2\theta}{dr^2} = \frac{T}{r^3}.$$

Hence, at a distance of one centimetre from the centre of the sphere, the pressure in the direction of the radius arising from inequality of temperature will be—

$$\frac{T}{p}\,0{\cdot}315 \text{ dynes per square centimetre.}$$

4. In Mr. Crookes's experiments the pressure, p, was often so small that this stress would be capable, if it existed alone, of producing rapid motion in small masses.

Indeed, if we were to consider only the normal part of the stress exerted on solid bodies immersed in the gas, most of the phenomena observed by Mr. Crookes could be readily explained.

5. Let us take the case of two small bodies symmetrical with respect to the axis joining their centres of figure. If both bodies are warmer than the air at a distance from them, then in any section perpendicular to the axis joining their centres, the point where it cuts this line will have the highest temperature, and there will be a flow of heat outwards from this axis in all directions.

Hence $\frac{d^2\theta}{dh^2}$ will be positive for the axis, and it will be a line of maximum pressure, so that the bodies will repel each other.

If both bodies are colder than the air at a distance, everything will be reversed; the axis will be a line of minimum pressure, and the bodies will attract each other.

If one body is hotter, and the other colder, than the air at a distance, the effect will be smaller; and it will depend on the relative sizes of the bodies, and on their exact temperatures, whether the action is attractive or repulsive.

6. If the bodies are two parallel discs, very near to each other, the central parts will produce very little effect, because between the discs the temperature varies uniformly and $\frac{d^2\theta}{dh^2} = 0$. Only near the edges will there be any stress arising from inequality of temperature in the gas.

7. If the bodies are encircled by a ring having its axis in the line joining the bodies, then the repulsion between the two bodies, when they are warmer than the air in general, may be converted into attraction by heating the ring, so as to produce a flow of heat inwards towards the axis.

8. If a body in the form of a cup or bowl is warmer than the air, the distribution of temperature in the surrounding gas is similar to the distribution of electric potential near a body of the same form, which has been investigated by Sir W. Thomson.[1] Near the convex surface the value of $\frac{d^2\theta}{dh^2}$ is nearly the same as if the body had been a complete sphere, namely, $2T\frac{1}{a^2}$, where T is the excess of temperature, and a is the radius of the sphere. Near the concave surface the variation of temperature is exceedingly small. Hence the normal pressure on the convex surface will be greater than on the concave surface, as Mr. Crookes has shown by the motion of his radiometers.

Since the expressions for the stress are linear as regards the temperature, everything will be reversed when the cup is colder than the surrounding air.

9. In a spherical vessel, if the two polar regions are made hotter than the equatorial zone, the pressure in the direction of the axis will be greater than that parallel to the equatorial plane, and the reverse will be the case if the polar regions are made colder than the equatorial zone.

10. All such explanations of the observed phenomena must be subjected to careful criticism. They have been obtained by considering the normal stresses alone, to the exclusion of the tangential stresses; and it is much easier to give an elementary exposition of the former than of the latter.

If, however, we go on to calculate the forces acting on any portion of the gas in virtue of the stresses on its surface, we find that when the flow of heat is steady, these forces are in equilibrium. Mr. Crookes tells us that there is no molar current, or wind, in his radiometer vessels. It may not be easy to prove this by experiment, but it is satisfactory to find that the system of stresses here described as arising from inequalities of temperature will not, when the flow of heat is steady, generate currents.

11. Consider, then, the case in which there are no currents of gas, but a steady flow of heat, the condition of which is

$$\frac{d^2\theta}{dx^2} + \frac{d^2\theta}{dy^2} + \frac{d^2\theta}{dz^2}\ (= -\Delta^2\theta) = 0.$$

(In the absence of external forces, such as gravity, and if the gas in contact with solid bodies does not slide over them, this is always a solution of the equations, and it is the only permanent solution.) In this case the equations of motion show that every particle of the gas is in equilibrium under the stresses acting on it.

Hence any finite portion of the gas is also in equilibrium; also, since the stresses are linear functions of the temperature, if we superpose one system of temperatures on another, we also superpose the corresponding systems of forces. Now the sys-

[1] Reprint of Papers on Electrostatics, p. 178.

tem of temperatures due to a solid sphere of uniform temperature, immersed in the gas, cannot of itself give rise to any force tending to move the sphere in one direction rather than in another. Let the sphere be placed within the finite portion of gas which, as we have said, is already in equilibrium. The equilibrium will not be disturbed. We may introduce any number of spheres at different temperatures into the portion of gas, and when the flow of heat has become steady, the whole system will be in equilibrium.

12. How, then, are we to account for the observed fact that forces act between solid bodies immersed in rarefied gases, and this, apparently as long as inequalities of temperature are maintained?

I think we must look for an explanation in the fact discovered in the case of liquids by Helmholtz and Piotrowski,[1] and for gases by Kundt and Warburg,[2] that the fluid in contact with the surface of a solid must slide over it with a finite velocity in order to produce a finite tangential stress.

The theoretical treatment of the boundary conditions between a gas and a solid is difficult, and it becomes more difficult if we consider that the gas close to the surface is probably in an unknown state of condensation. We shall, therefore, accept the results obtained by Kundt and Warburg on their experimental evidence.

They have found that the velocity of sliding of the gas over the surface due to a given tangential stress varies inversely as the pressure.

The coefficient of sliding for air on glass was found to be $\lambda = \frac{10}{p}$ centimetres, where p is the pressure in millionths of an atmosphere. Hence at ordinary pressures λ is insensible, but in the vessels exhausted by Mr. Crookes it may be considerable.

Hence if close to the surface of a solid there is a tangential stress, S, acting on a surface parallel to that of the body, in a direction h, parallel to that surface, there will also be a sliding of the gas in contact with the solid over its surface in the direction h, with a finite velocity $= S\frac{\lambda}{\mu}$.

13. I have not attempted to enter on the calculation of the effect of this sliding motion, but it is easy to see that if we begin with the case in which there is no sliding, the effect of permission being given to the gas to slide must be in the first place to diminish the action of all tangential stresses on the surface without affecting the normal stresses; and in the second place to set up currents sweeping over the surfaces of solid bodies, thus completely destroying the simplicity of our first solution of the problem.

14. When external forces, such as gravity, act on the gas, and when the thermal phenomena produce differences of density in different parts of the vessel, then the well-known convection currents are set up. These also interfere with the simplicity of the problem and introduce very complicated effects. All that we know is that the rarer the gas and the smaller the vessel, the less is the velocity of the convection currents; so that in Mr. Crookes's experiments they play a very small part.

Mathematical Society, April 11.—C. W. Merrifield, F.R.S., vice-president, in the chair.—Mr. Artemas Martin, Pennsylvania, was elected a Member, and Messrs. W. M. Hicks and T. R. Terry were proposed for election.—The Chairman, on the recommendation of the Council, nominated Messrs. Brioschi, Darboux, Gordan, Sophus Lie, and Mannheim for the honour of Foreign Membership.—Prof. H. J. S. Smith, F.R.S., vice-president, read two papers: second notice on the characteristics of the modular curves, and a note relating to the theory of the division of the circle.—Mr. Tucker communicated a letter from Prof. Tait, and read an abstract of a paper by Prof. Minchin on the astatic conditions of a body acted on by given forces, and a portion of a paper by Mr. C. Leudesdorf on certain extensions of Frullani's theorem.

Royal Astronomical Society, April 12.—Lord Lindsay, president, in the chair.—A paper was read by Capt. Abney, R.E., F.R.S., on photography at the least refrangible end of the solar spectrum, and some photographs of spectra of great interest were exhibited to the Fellows. Some discussion ensued, and Dr. De la Rue asked a question respecting colour photography; Capt. Abney attributed such phenomena to different degrees of oxidation of the spectrum. The President brought up Dr. Draper's discoveries, but Capt. Abney declined to speak upon that subject.—The Astronomer-Royal remarked upon the proposal to set up a statue of the late M. Leverrier, showing that the gratification and pride which the neighbours of such a great luminary would naturally take in setting up his monument ought not to be snatched from them by the intervention of strangers. It was also pointed out that the charter of the Society does not admit of any subscription in its corporate capacity.—Mr. Christie read a letter from Mr. Ellery upon Mars at opposition, 1877. It appeared that the planet was very ill-defined, and not much good could be done with it.—Mr. B. G. Jenkins read a paper on the transit of Mercury, summarising the history of such phenomena, and referring to the spot of light on the disc and the ring round the limb, and their variations corresponding with perihelion and aphelion transits. Mr. Chambers suggested that if this paper were published before next transit it would be of great value, whereas, according to the practice of the present editor of the *Notices*, that would not be done. Prof. Cayley, the editor, made the proper excuses for the lateness of the publication.—The Astronomer-Royal announced his intention to assist competent observers, who wished to observe the transit, by giving them the use of the telescopes which were employed for the transit of Venus.—Mr. Green read a letter from Prof. Schiaparelli on Mars as seen recently a long time after opposition, and showed some curious drawings.

Chemical Society, April 18.—W. Crookes, F.R.S., in the chair.—The following papers were read:—On terpin and terpinol, by Dr. Tilden. The author prepared crystallised terpin, $C_{10}H_{20}O_2 . OH_2$, by Wigger's process, and obtained the same compound from American and French terpentine, but did not procure any crystalline substance from the terpenes of the orange group. By the action of dilute hydrochloric acid on terpin, an oily body, terpinol, boiling 205°–215°, was obtained, having the formula, $C_{10}H_{18}O$. By the action of dry hydrochloric acid on terpinol, a dihydrochloride was prepared. The author believes that in the preparation of terpin by the ordinary process, terpinol is formed at a certain stage of the reaction. By acting on terpin with dilute sulphuric acid, a hydrocarbon, $C_{10}H_{16}$, boiling at 176°–178°, sp. gr. 0·8526 was obtained; it is optically inactive, and gives no crystalline deposit with hydrochloric acid, and no crystalline nitroso compound; the author proposes to call it terpinylene.—The poisonous principle of *Urechites suberecta*, by J. J. Bowrey. This plant grows wild in Jamaica; it has dark green leaves and large bright yellow flowers; it is locally called "nightshade." It is known to be very poisonous. The author has extracted from the fresh leaves of the plant, by the use of alcohol, water, and a temperature not exceeding 38° C., a white crystalline body, urechitin, $C_{28}H_{42}O_8$, to the presence of which the plant owes its poisonous properties. It is very soluble in hot alcohol, chloroform, and glacial acetic acid; almost insoluble in water and dilute spirit. It is intensely bitter, and very poisonous; it gives, with strong sulphuric acid, a characteristic colour reaction. The liquid passing from yellow through red to purple, a trace of nitric acid increases the rapidity of the colour-changes. If the leaves are dried at 100°, urechitoxin is obtained, either crystalline or amorphous. This substance resembles urechitin in its chemical and toxical properties. Both substances are glucosides.—The temperature at which some of the alkaloids, &c., sublime as determined by an improved method by A. W. Blyth. The author has determined the melting and subliming points of many active vegetable principles, and classed them as regards their behaviour to heat for practical purposes. He has also devised a new method for determining subliming points: it consists essentially in placing the substance on a thin cover glass floating on a bath of mercury, and examining a second cover glass placed over the substance, from time to time with a ¼-inch objective, the mercury being gradually heated.

Entomological Society, April 3.—H. W. Bates, F.L.S., F.Z.S., president, in the chair.—Miss E. A. Ormerod was elected a Member of the Society.—Mr. McLachlan remarked that the opinion expressed by Mr. J. P. M. Weale at the last meeting as to the functional purpose of the cephalic process in *Termes triniverius*, was corroborative of an observation already recorded in Hagen's "Monographie der Termiten."—Mr. F. Grut exhibited, on behalf of the Rev. T. A. Marshall, a collection of insects which that gentleman had made in the Windward Islands.—Mr. F. Smith exhibited a series of specimens of a species of "harvesting ant" sent to Mr. Darwin from Florida by Mrs. M. Treat. Three series showed a gradation from large soldiers and small workers, all having acutely dentate

[1] Wiener Sitzb., xl. (1860), p. 607.
[2] Pogg. Ann., clv. (1875), p. 337.

mandibles, to other ants of all sizes with mandibles having rounded teeth, and other specimens in which the teeth were obsolete. It was not, however, made clear whether intermediate forms of teeth were found in nests, or whether three distinct races existed. The species appeared to be identical with *Myrmica barbata* from Texas.—Mr. A. A. Berens exhibited two examples of *Thestor mauritanicus* taken on the Atlas Mountains. —Mr. McLachlan exhibited a coleopterous larva sent from Zanzibar by Dr. Kirk. He also exhibited a portion of the stem of a coffee-tree which had been bored into by this larva, and which was especially remarkable on account of the presence of a series of conical holes which opened a communicator between the inner gallery and the atmosphere.—Mr. W. C. Boyd exhibited and made some remarks on a specimen of *Pterophorus lætus* taken at Deal.—The Secretary read a paper communicated by the Rev. T. A. Marshall, entitled "Notes on the Entomology of the Windward Islands."—The Rev. H. S. Gorham communicated descriptions of new species of Cleridæ, with notes on the genera and corrections of synonymy.—Dr. D. Sharp communicated a paper on some Nitidulidæ from the Hawaiian Islands.—The Secretary read a paper by Mr. J. P. M. Weale, entitled "Notes on South African Insects," and exhibited drawings made by the author in illustration.—Mr. Wood Mason exhibited and made remarks on the insects referred to in the foregoing paper, and was followed by Mr. Meldola on the same subject.—The following papers were also communicated:—On display and dances by insects, by Mr. A. H. Swinton; and On the secondary sexual characters of insects, by Mr. J. W. Slater. —Part V. of the *Transactions* for 1877 was on the table.

Geological Society, March 20.—Henry Clifton Sorby, F.R.S., president, in the chair.—John William Head was elected a Fellow of the Society.—The following communications were read:—On the chronological value of the triassic strata of the south-western counties, by W. A. E. Ussher, F.G.S.—Note on an *Os articulare,* presumably that of *Iguanodon mantelli,* by J. W. Hulke, F.R.S., F.G.S.—Description of a new fish from the lower chalk of Dover, by E. Tulley Newton, F.G.S.—Further remarks on adherent carboniferous productidæ, by R. Etheridge, jun., F.G.S.—The submarine forest at the Alt Mouth, by T. Mellard Reade, F.G.S.

Institution of Civil Engineers, April 20.—Mr. Bateman, president, in the chair.—The papers read were descriptive of three bridges on the Punjab Northern State Railway, viz., "The Ravi Bridge," by Mr. R. T. Mallet, M. Inst. C.E.; "The Alexandra Bridge, over the Chenab," by Mr. H. Lambert; and "The Jhelum Bridge, by Mr. F. M. Avern, M. Inst. C.E.

Victoria (Philosophical) Institute, May 6.—A paper on the physical geography of the East, by Prof. J. L. Porter, LL.D., was read. A discussion ensued, in which many Eastern explorers and others took part.

PARIS

Academy of Sciences, April 29.—M. Fizeau in the chair.—The following among other papers were read:—The theory of germs and its applications to medicine and surgery, by MM. Pasteur, Joubert, and Chamberland. It is shown to be possible to produce at will purulent affections either putrid or without any putrid element, or anthracic, or variable combinations of these kinds of disorder, according to the specific *microbes* that are caused to act on the living organism.—Experiments relating to the heat which may have been developed by mechanical actions in rocks, especially in clays; consequences for certain geological phenomena, notably for metamorphism, by M. Daubrée. He measured the rise of temperature produced in hard clay passed between rotating cylinders and between fluted cones; also the effect of pug-mills. In one case of pug-mill action for an hour the rise was more than 30°. For the same times, however, the heating effect is greater with cylindrical rollers.—Experiments with a view to determine the true origin of the chorda tympani, by M. Vulpian. These favour the conclusion that the nerve proceeds not from the facial nerve nor the intermediate nerve of Wrisberg, but from the trigeminus.—On magnetic rotation of the plane of polarisation of light under the influence of the earth, by M. Becquerel. Between a Jellet polariser and an analyser, with telescope and divided circle, is placed a tube (0·5 m. long) with parallel glass ends and containing sulphide of carbon. By means of terminal plane mirrors the luminous ray is successively reflected, the rotation being thus increased. The luminous ray comes to the eye after traversing the tube five times. Now, if the system be placed in the plane of the magnetic meridian, the plane of polarisation is not the same in looking north and in looking south; there was an angular differece of about 6'·5 between these positions. On the other hand, when the system is placed at right angles to the magnetic meridian, the same direction of the plane of polarisation is got, whether one looks east or west, and it is the bisecting position of the former two. The angular difference is considered due to the action of the earth.—Suppression of the return wire in use of the telephone, by M. Bourbouze. Connecting to earth by means of plates of gilt copper about 1 m. by 2 ctm., placed at 40 to 50 ctm. depth in garden soil, he got more distinct transmission.—On the transparency of coloured flames for their own radiations, by M. Gouy. Two layers of incandescent vapour, of the same density and temperature, but of very unequal thickness, give very different spectra. One cannot, from an examination of the lines of any spectrum, draw any conclusion as to the physical state of the vapours producing it, unless their thickness be known and taken into account.—On the solution of platinum in sulphuric acid, by M. Scheurer-Kestner. In apparatus of ordinary concentration the solution varies from 1 gramme to 8 grammes per. ton of concentrated acid, according as the product obtained contains 94 or 99 per cent. of monohydrated acid; with fuming acid the quantity of metal may amount to 1,000 grammes. But by lowering of the boiling point and diminution of the platinum, as in Kesler's apparatus, the loss of metal may be greatly lessened. —On the vapour density of sulphide of ammonium, by M. Salet. He experimented by mixing at 80° known volumes of sulphuretted hydrogen and of ammonia; in no case was any contraction observed.—Experiments on the effects of lateral compression or crushing in geology, by M. Favre. In these experiments a layer of clay was made between two blocks of wood fixed on a piece of caoutchouc, which was first stretched and, after receiving the clay, was allowed to contract. Various phenomena of mountain chains were thus reproduced.—On the daily oscillation of the barometer, by M. Cousté. He considers it due to variations (1) in the quantity of atmospheric vapour of water, (2) in vertical ascending currents formed partly by the dilated air, but more by the water vapour developed by the sun in the low and middle layers, condensed anew in the upper layers.—Remarks on a letter of M. Wolf, on the period of daily variations of the inclination needle, by M. Faye. He gives a table of sun-spot minima covering 267 years, and showing 11·11 years as the period.—On the ultra-violet absorption spectra of earths of gasolinite, by M. Soret. The lines of a new base were observed.

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