THURSDAY, MAY 16, 1878

THE MICROPHONE

WE were enabled to announce a fortnight ago, that Prof. Hughes, the inventor of the type-printing telegraphic apparatus which goes by his name, has made the wonderful discovery that certain bodies are sensitive to sound, in the same way as selenium is sensitive to light. That is to say, if we place these bodies in the circuit of a small battery, and subject them to sound-vibrations, in other words, talk at them, the electric current continually passing through it will be so continuously modified by the voice that the object may be used instead of a telephone for sending a message.

Since our note was penned an opportunity has been afforded us by the kindness of Prof. Hughes, of inquiring into the precise manner in which this and other startling results have been accomplished.

The impression left upon us by a careful following of all Mr. Hughes's experiments, is, that by them we are brought face to face with one of the most wonderful discoveries of the century. To see Prof. Huxley, who was one of those present, solemnly talking at a small glass tube about two inches long, was, in itself, a sight worth seeing; but to go into another part of the house, and, on putting a telephone to the ear to find that the talking at the glass tube there resulted in a quite perfect, very easily audible reproduction of the quality of every word which the Professor uttered, was a thing almost transcending the marvellous.

That by such experiments as these we are beginning to tap sources and modes of energy hitherto undreamt of was rendered most evident by an experiment which has suggested the name, placed at the head of this article, for the instrument by which it is accomplished. The delicate rubbing of a fine camel's hair pencil over a smooth wooden surface under certain conditions of contact, although, of course, inaudible in the ordinary way, was rendered evident in the telephone by a crackling noise, of which the intensity was almost painful to the ear. In this way Mr. Hughes has enabled Mr. Preece to hear a fly walk; we were not so fortunate as to hear this, because the only small fly available in the room, after having been carefully hunted down and inclosed in a small tumbler, obstinately declined to walk on the wood.

We have said so much by way of giving an idea in the first instance of the manner and result of the experimentation. The kind of inquiry into the molecular structure of bodies it renders possible, and the applications to which, undoubtedly, it will soon be put, will be best grasped after a somewhat detailed description of the apparatus itself. This description was given by Mr. Hughes at the meeting of the Royal Society held on Thursday last, and it may safely be said that never was a more difficult problem presented to men of science by simpler apparatus.

Although a telephone, as will be seen, is part of the apparatus utilised, the total problem presented by Mr. Hughes is a very much more complex one than that presented by that most marvellous of modern instruments.

Mr. Hughes has employed the telephone as a phonoscope of the greatest delicacy, to detect variations in currents, and the consequent reproduction of sound. The materials experimented upon by him were arranged as in the following sketch, in which B represents a battery, S the source of sound or material examined, and T the telephone or phonoscope.

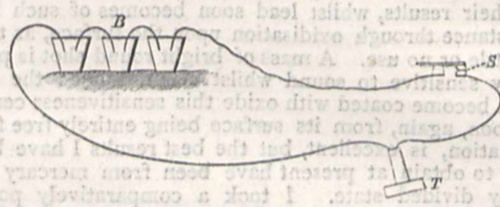

FIG. 1.

The battery was a simple Daniell's cell, of Minotto's form, made by using three common tumblers, a spiral piece of copper wire being placed at the bottom of each glass and covered with sulphate of copper, and the glass being then filled with well-moistened clay and water. A piece of zinc as the positive element was placed upon the clay. Insulated wires were attached to each plate, and three of these cells were joined in series.

All experiments were made on a closed circuit.

Prof. Hughes's work was begun by studying the effect of strains, Sir W. Thomson and others having shown that the resistance offered by wires to currents is affected by them, it followed that as the conveyance of sound vibrations must induce variations in strains, the wire resistance should vary when it was used to convey sound.

A stretched wire was therefore, in the first instance, introduced at S. The wire was talked at, but no effect was marked until a breaking strain was applied; at the moment of breaking, a sound was heard. Next, the broken ends were pressed together. The next stage in the experiments we quote from the paper itself:—

"It was soon found that it was not at all necessary to join two wires endwise together to reproduce sound, but that any portion of an electric conductor would do so even when fastened to a board or to a table, and no matter how complicated the structure upon this board, or the materials used as a conductor, provided one or more portions of the electrical conductor were separated and only brought into contact by a slight but constant pressure. Thus, if the ends of the wire terminate in two common nails laid side by side, and are separated from each other by a slight space, were electrically connected by laying a similar nail between them, sound could be reproduced. The effect was improved by building up the nails log-hut fashion, into a square configuration, using ten or twenty nails. A piece of steel watch-chain acted well. Up to this point the sound or grosser vibrations were alone produced, the finer inflections were missing, or, in other words, the *timbre* of the voice was wanting, but in the following experiments the *timbre* became more and more perfect until it reached a perfection leaving nothing to be desired. I found that a metallic powder such as the white powder—a mixture of zinc and tin—sold in commerce as "white bronze," and fine metallic filings, introduced at the points of contact, greatly added to the perfection of the result."

Here, then, was articulate speech clearly reproduced.

Prof. Hughes's next efforts were to discover the best material and form to give to his apparatus.

"Although I tried all forms of pressure and modes of contact, a lever, a spring, pressure in a glass tube sealed up while under the influence of strain, so as to maintain the pressure constant, all gave similar and invariable results, but the results varied with the materials used. All metals, however, could be made to produce identical results provided the division of the metal was small enough, and that the material used does not oxidise by contact with the air filtering through the mass. Thus platinum and mercury are very excellent and unvarying in their results, whilst lead soon becomes of such high resistance through oxidisation upon the surface, as to be of little or no use. A mass of bright round shot is peculiarly sensitive to sound whilst clean, but as the shot soon become coated with oxide this sensitiveness ceases. Carbon, again, from its surface being entirely free from oxidation, is excellent, but the best results I have been able to obtain at present have been from mercury in a finely divided state. I took a comparatively porous non-conductor, such as the willow charcoal used by artists for sketching, heating it gradually to a white heat and then suddenly plunging it in mercury. The vacua in the pores, caused by the sudden cooling, become filled with innumerable minute globules of mercury, thus, as it were, holding the mercury in a fine state of division. I have also tried carbon treated in a similar manner with and without platinum deposited upon it from the chloride of platinum. I have also found similar effects from the willow charcoal heated in an iron vessel to a white heat, and containing a free portion of tin, zinc, or other easily vaporised metal. Under such conditions the willow carbon will be found to be metallised, having the metal distributed throughout its pores in a fine state of division. Iron also seems to enter the pores if heated to a white heat without being chemically combined with the carbon as in graphite, and, indeed, some of the best results have been obtained from willow charcoal containing iron in a fine state of division.

"Pine charcoal treated in this manner (although a non-conductor as a simple charcoal) has high conductive powers, due to the iron; and from the minute division of the iron in the pores, is a most excellent material for the purpose."

The substances above referred to are in practice confined in a glass tube or box, and provided with wires to enable them to be easily inserted into a circuit. This is called a transmitter.

The resistance of the conductors employed is affected by sounds absolutely inaudible, and it is this quality which Prof. Hughes utilises in what he calls *par excellence* his *microphone*. This marvellous instrument, of which we shall hear so much in the future, consists of a lozenge-shaped piece of gas-carbon one inch long, ¼ inch wide at its centre, and ⅛ of an inch thick; the lower pointed end pivots upon a similar block, the upper rounded end plays free in another carbon block; all these pieces of carbon are tempered in mercury, and carbon is used in preference to any other material, as its surface does not oxidise. Prof. Hughes, in his paper, states:—

"The best form and materials for this instrument, however, have not yet been fully experimented on. Still, in its present shape, it is capable of detecting very faint sounds made in its presence. If a pin, for instance, be laid upon or taken off a table, a distinct sound is emitted, or, if a fly be confined under a table-glass, we can hear the fly walking, with a peculiar tramp of its own. The beating of a pulse, the tick of a watch, the tramp of a fly, can thus be heard at least a hundred miles distant from the source of sound. In fact, when further developed by study, we may fairly look for it to do for us, with regard to faint sounds, what the microscope does with matter too small for human vision."

The construction of the tube-transmitter exhibited to the Royal Society will be seen from the annexed woodcut. It consists of an exterior glass tube, G, two inches long and ¼ inch in diameter; in it are four separate pieces of willow charcoal. A is made to press on B, C, D, E, and F, until the resistance offered to the current is about one-third that of the line on which it is to be employed.

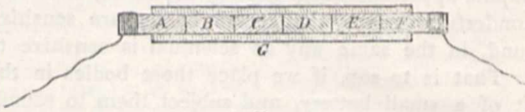

FIG. 2.

As Prof. Hughes properly remarks, it is as yet impossible to say what effect will flow from this wonderful discovery, a discovery which shows that it is possible to transmit clear and intelligent articulate speech, and to render the inaudible audible by the mere impact of sound waves upon matter along which an electric current is flowing.

It is not too early, however, to see that we have in the microphone a new method of attaching and quantifying molecular motions.

PHYSICAL SCIENCE FOR ARTISTS[1]

II.

THE examples I gave in my last paper were tested by a reference to the probable action of the aqueous vapour of our atmosphere in absorbing the various constituents of sunlight—the sun being the great source of light with which artists are specially concerned.

The reason that such a test was not applied long ago was because we are only just now beginning to understand why it is that the sun shines; why its light is white, and again why it is that this white light in passing through a great thickness of our atmosphere as it must do at sunrise and sunset—when the beams graze the surface of the earth instead of impinging upon it at a high angle—is in great measure absorbed or used up before it gets to the eye. The result of the condition to which I have just referred is familiar to all; at sunrise and sunset the sun is red and not white.

The light of the sun we know now is due to the quivering or vibration of the molecules of the matter of which the sun is composed. No molecular vibration no light; given molecular vibration, the more intense it is the more intense is the light produced. The absorption of the sunlight by our air in the manner I have stated is due to the molecules of our air already in vibration being set in still stronger vibration by the sunlight passing through them. Here again then we have molecules and vibrations. In short the vibration of molecules, so far as light is given out or reflected or quenched by them, sharply defines the physical region in which artists are chiefly interested.

In a work which recently appeared,[2] I have tried to show how the actions involved in sending a telegraphic message may help us to form a mental image of what goes on before the sensation of light is produced; we have a sending instrument, a medium, and a receiving instrument.

[1] Continued from p. 31.
[2] "Studies in Spectrum Analysis."

The first, under all circumstances, is a molecule or series of molecules in vibration, and the quality of the light depends upon the vibration either inherent in the molecule or dependent upon the quality of the energy which sets it in vibration or controls the vibration.

The second is the ether, which does for light what our atmosphere does for sound. Competent to transmit vibrations of all lengths without loss of energy, it behaves with perfect fairness, so to speak, to light of all kinds.

The third, the receiving instrument, in our case is the eye of the artist above all things, but not to the exclusion of everything else, because every object which reflects light must receive it first, and sometimes important modifications are brought about in the act of reflection. To mention two instances :—white light from the sun falls on a leaf, but leaves appear green by the light which they reflect, and this transformation is the result of molecular work. The light of the moon is yellow in comparison with sunlight for the same reason, and the difference between sunlight and moonlight effects has its origin in the lunar molecules.

We call the light of the sun white, and much of the action of light may be studied by supposing this light to be a simple thing, by which I mean non-compound. A hole in a shutter through which the sun shines will convince us that light travels in straight lines. The idea of a modern novelist that light can travel spirally through a key-hole is not based on fact.

It may happen, too, if there be a brightly illuminated object outside the hole in the shutter, that another point not to be neglected will be illustrated. Because light does travel in straight lines the various rays coming from the different parts of an object and passing through a small aperture will build up an inverted image of it on the other side of the aperture. The most obvious bearing of this in artist's work is that if the sun shines through the narrow apertures left by leaves in a thick wood, we shall have images of the sun on the ground; the shadows of the leaves will be dominated by circular intervals, and the higher the leaves the larger these circles will be. During the eclipse of 1870 the images of the delicate crescent of the sun thrown on the ground through the orange and olive trees were most perfect in form, and produced a strange effect never to be forgotten.

The laws of reflection can also be studied without any higher knowledge of the properties of light, and the difference between "specular reflection," the case in which light is reflected as in a mirror, and "scattering," in which, in consequence of the roughness of the surface on which it falls it is thrown off in all directions, will be at once recognised.

Water is the great reflector employed by the artist. Take, for instance, No. 643 in this year's Academy. If a painter will imagine a vertical plane passing through the object reflected—say a hill-top, and his eye; and plot a section with the height of his eye and the hill-top above the water and the distance between them roughly to scale; and if he will further recollect that the lines which connect the reflecting point of the water with his eye and the hill-top must make equal angles with the water level, he will find all he needs to insure correctness. In a picture taken, *e.g.*, with the eye at *a*, in the annexed woodcut, he will not include the distant hill-top at *y*, while with the eye at *b* he would do so.

In tranquil water the same consideration determines the locus of the reflection of the sun or moon. But if there be scattering, there will be a wake. The above

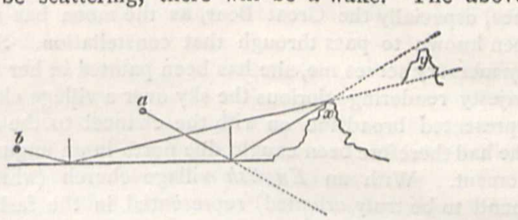

Fig. 1.

reasoning will show that it will be absolutely incorrect to throw this wake athwart the picture; nevertheless, this has been done, and by artists of the highest celebrity.

It is, perhaps, in the case of reflection of light by the poor moon that the modern artist comes to the greatest grief; and yet the only peculiarity in this case of reflection of light is that we are dealing with reflection from a spherical body which changes its place with reference to the light source and our eyes. If an artist would amuse himself any evening with his children in imitating these conditions with a lamp and some oranges he would never make another mistake. We should have moons painted with discretion instead of *à discretion*, and I fancy the "balance of the picture" would be found to be much less frequently disturbed by scientific accuracy than is generally imagined. I have known an artist to defend a crescent moon directly opposite a setting sun on the ground that if the moon had been painted full this much-prized "balance of the picture" would be entirely upset; and yet when it was suggested that the effect of two moons should be tried the idea was scouted as ridiculous—why, I could not understand from the standpoint taken by the artist.

Five minutes' reading of any elementary astronomy is all that is necessary to show that when the moon is on one side of the horizon, say east, and the sun on the other, say west, the observer must be between them, and that therefore the moon's reflecting side in its entirety must be turned towards him. It will not want even this amount of reading to convince him that if a sunset is painted as in Fig. 2, by no possibility can a globe at

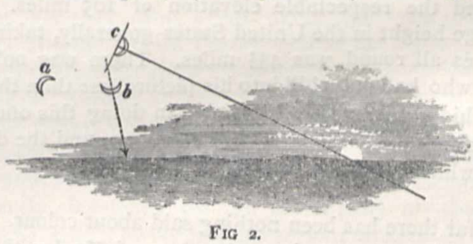

Fig 2.

a be lighted up, as shown. Nor can it be lighted up by the sun as shown at *b*, because the sun must be somewhere on the dotted line. If the moon is drawn at *c* the illumination must be symmetrical with reference to the line joining the moon and sun, and the nearer the moon is apparently to the sun, the more delicate must the crescent be.

Enough for the present on this subject. There is, however, one other point worth notice, which, although it is more astronomical than physical, I may perhaps be allowed to refer to here. When an artist wishes to introduce a constellation as well as a moon into his picture, he should especially avoid the familiar northern ones, especially the Great Bear, as the moon has never been known to pass through that constellation. Still if my memory serves me, she has been painted in her silent majesty rendering glorious the sky over a village church, represented broadside on with the chancel to the right. She had therefore been caught due north in an unguarded moment. With an *English* village church (which is bound to be truly oriented) represented in the fashion I have indicated it is also as well to avoid the temptation to show up the stained glass windows of the aisles by introducing a sunset behind them.

I wish to be as little digressive as possible, but there is one point more which demands a word in passing. If an artist will put the moon or the sun into a picture, he should understand that in nine cases out of ten he lays down an almost perfect scale by which the accuracy of his delineation of landscape may be tested. In spite of the strange physiological effect which gives us the exaggerated sensation of the size of the sun or moon when they are near the horizon (so that we can compare them with familiar objects), the real variation is practically *nil*, and for our purpose it is enough to say that both sun and moon steadily subtend an angle of half a degree. Now it is because we can observe this angle and because we know the distance of the sun and moon as well, that we can calculate the sizes of these luminaries. Similarly, if an artist paints Peckham Rise from Camberwell or Mount Everest from the valley of Cashmere (supposing either picture possible—I don't know), and then puts a sun or moon in, *par dessus le marché*, he gives all the data necessary for the determination of the height and size of the hills in question.

By the kindness of an American astronomer I can give some statistics of considerable interest on the heights of hills in the United States as roughly surveyed in this way—that is as determined by pictures in which, by means of the moon or otherwise, the necessary data are provided. The pictures on which they are based were exhibited in 1876 and 1877. One mountain (I think it was in Missouri, but its exact name has escaped me) reached the respectable elevation of 105 miles. The average height in the United States generally, taking the pictures all round, was $43\frac{3}{4}$ miles. There was only one artist who had got a hill into his picture less than thirteen miles high, but he only succeeded in doing this once.

So much then with regard to reflection, and the digressions which reflection has suggested.

So far there has been nothing said about colour.

It has been known from the time of Kepler that the white light of the sun, and indeed of all bodies which emit it, is not the simple thing we have so far taken it to be. It is really a sensation produced in our eye by the commingling of an innumerable series of different wave-lengths of light, each one of which, taken separately, we are bound to consider as a pure colour from the physical point of view, however we regard the physiological action which gives rise to the sensation.

Nature shows us in the rainbow, about which I shall have something to say by and by, the breaking up of this complex beam of white light into its various elements. The physicist arrives at the same result by employing a prism. A round hole in a shutter, through which a beam of light is allowed to enter into a dark room, and a common lustre inserted in the path of the beam, is all that is required in the way of apparatus to demonstrate the marvellous phenomenon of the analysis of white light into its constituent elements.

We not only get colour as the result of the analysis of white light, but we get it as a result of molecular structure, that is, some bodies like the sun and a candle give us that kind of light which we can break up into a complete series of coloured constituents; other bodies give us light which is not white, which is coloured to begin with, and so remains coloured to the end of the chapter.

Let us now pass on to those principles, the application of which to the coloured phenomena with which artists have to deal will, I am sure, prove of the greatest interest. Here we must grope our way as well as we may be able in a region where at present the senses are entirely powerless. We are in the world of the infinitely little. We approach one of those questions of molecular physics which no doubt in a few years must become one of the chief fields of investigation to men of science.

If I take a lump of iron, it is in what is generally called the solid state. If I apply heat to it it becomes molten, and we call it liquid. If the heat is still further increased, we drive the molten iron into iron vapour, as we more commonly drive water into steam.

Now we have achieved these results gradually, breaking down the molecular structure of the iron and of the water until at length we have got the molecular structure down to that of its ultimate fineness; so that when we have got to the stage of vapour at the end of our labour we have got a condition of things in which the smallest particles, or the ultimate molecules, which go to make up iron and water are there in their individuality and exist as separate points.

Now, what can this have to do with colour?

It has this to do with it: if I make a lump of iron hot, it gives out light, because its molecular constitution is disturbed or rendered more disturbed by the conditions to which we expose it when we heat it, and this state of unrest is rendered visible to us by the phenomena of light. Here we have simply the reason why there is a visible universe at all. If it were not for the condition of unrest of matter, we should never see anything; and, therefore, so far as the sensation of light is concerned, the visible universe would cease to exist altogether if this condition of unrest were abolished.

This being so then, let us take each of those molecular groupings in the solid iron as being in a state of unrest. Let us take for granted that the phenomena of sight depend first upon the state of unrest; secondly, upon the state of unrest being communicated to the surrounding ether, which, as we have already seen, does for light what air does for sound; and that the state of unrest of the molecules of iron having set up an equivalent state of unrest in the ether, or, if you like it better, having set up a chain of vibrations in the ether, this ether is competent to communicate its own vibrations thus imposed upon it to the optic nerve in our eye.

It brings before that nerve such an accurate reproduction, so to speak, of the vibrations which were communicated to it at the other end by the vibrations of the molecules of iron, that we have the impression that we see a mass of white hot iron, because the ether was agitated by precisely a mass of white hot iron in the first instance.

Now, if we observe any mass such as this, giving us light in the ordinary way, we get merely the impression of form; but if we admit such white light to our eye through the prism, we get it transformed into a band of colour called a spectrum, because, as we have already seen, white light is built up of a gamut of light notes from the lowest note to the highest; that is—to talk in the language of colour—from the extreme red to the extreme violet, through all those colours which are so gloriously brought before us in the rainbow, and more too.

But this does not happen with all substances.

Let us go now from our mass of white hot iron back to those smallest particles of iron vapour, those ultimate molecules to which I first drew attention. If we subject the light which comes from them to the same treatment, that is, if we allow it to come to our eye through a prism, we find that we don't get the whole gamut of colour represented as in the former case. We only get a light note, so to speak, here and there. Ordinarily, the phenomenon is presented to us in consequence of the construction of the spectroscope, by a series of lines, because ordinarily the spectroscope, is so arranged that the vibrations from any set of molecules are made to paint for us images of a fine aperture called a slit, through which the light is made to pass. If the light is discontinuous so far as the gamut of light is concerned, we only get a light note here and there. If it is continuous, the series of images is continuous; and we get what is termed a continuous spectrum, that is, the band of rainbow tints.

Now, mark this well, that when we treat the vapours of all metals that we know of in this way, we find that the arrangement of these bright lines, the arrangement of the images of the slit in other words, is different in the case of the vapour of every metal, so that we may say that no two vapours in Nature have the same colour.

We are now justified in saying, speaking in the language of molecules, that when we drive any chemical substance down to its ultimate fineness, and cause the ultimate molecules of each such chemical substance to vibrate, the vibrations from each chemical substance communicated to the ether and by the ether to our eye are so distinct that if we will take the trouble to record the effects thus obtained, we are for ever afterwards able to recognise the vibrations of that particular molecule, in whatever conditions we see those vibrations thus rendered spectroscopically visible to us, whether the molecules we are examining are in our laboratory, or in the most distant body in the depths of space.

The blue part of the spectrum which we obtain when we examine the light which is communicated to our eye by the vibrations of the finest particles of manganese, to take an example, contains a series of lines absolutely without any arrangement—a broad band here, a single line there, a double line elsewhere, and so on. In iron the arrangement of the lines is perfectly different. They are more numerous, and a detailed examination would convince us that it is quite as easy to make as definite a map of such a spectrum, and thus to point out the differences, as it is easy to make a map or drawing of any two things which differ in themselves.

This is sure and certain knowledge. It seems to deal with a condition of things with which the artist will never have to do. This is so, but the necessity for the statement of these facts will be abundantly seen in the sequel in which I hope to show that between the two extreme molecular stages to which I have drawn attention, that which always gives us white light, and that which gives us coloured light, the colour *in no case* being the same, we have stages with coloured light which practically is *always the same* for all bodies.

J. NORMAN LOCKYER

THE AMERICAN STORM WARNINGS[1]

STORM movements from west to east over Europe are familiar to your readers, yet I will refer briefly to them here. The chief storm routes are as follows:—From the regions immediately north of the British Islands to the Norwegian coast and over the Scandinavian Mountains to the Eastern Baltic and Central Russia, thence crossing the Ural Mountains into Siberia. From the British Islands directly to Denmark, North Germany, and Southern Russia to the regions north of the Caspian Sea, and from the British Channel, over the Netherlands, to Central Europe, passing north of the Alps into the Danube valley, and over the Black Sea to Asia Minor. The influence of position of the area of high pressure southward of the storm track on the direction of the latter is very great. Whenever the first described route is followed, the pressure is high over Great Britain, France, and Central Europe, and is falling in the Mediterranean and Northern Africa. If the second route is taken by the storm the barometer is high over Spain and the Mediterranean, giving the zone of low pressure a generally eastern direction. When the last-described route is followed, the pressure is high in the Atlantic off the coast of France and Spain, leaving a relatively low pressure over Great Britain, Southern Norway, and Sweden, the Western Baltic, and Central Europe.

The heaviest rains occur along the west coast of France and the British Islands, and on the Norway coast. The precipitation lightens eastward and south-eastward to Central Europe, but seems to increase again in the Danube valley, where the influence of moist air from the Mediterranean basin operates in increasing the energy of the storm. Over the whole field minor disturbances are frequently developed by the movements of the high pressures, which rarely become serious storms.

We must regard a knowledge of the general movement of the atmosphere as essential to success in the prediction of the movements of storms, their arrival in different regions, and their character. During the past year I have followed out and depended on the operation of what I conceive to be a law of atmospheric movement which I deduced from observations of the changes that occur over the areas of the American and European continents

[1] Continued from p. 34.

and of the Atlantic Ocean. I was early struck with the incompleteness of a theory which implied the development and movement of detached areas of high and low barometer, especially as such areas must be traced with more or less irregular but distinct outlines. I soon found that in order to justify the appreciation of the term "area" to such figures representing particular conditions, the pressures over large spaces between them should be left practically unaccounted for, and that the most singular alignments of isobars which appear on the weather charts of the United States Signal Service Bureau, and of the European observatories, would not satisfy the want. I became convinced that the lack of continuity in the recognised systems of high and low pressures was a vital fault which affected the whole fabric of weather prediction. Following the investigation from day to day, I found that these areas, so called, performed their procession across the weather chart with a very striking regularity, and that they maintained relations toward each other which gave me an idea of their general arrangement and distribution over the field of observation. By a practical application I found that the zone theory of pressures fulfilled all my expectations. By means of the facilities for cabling daily observations from Europe afforded by Mr. Bennett, and through the agency of the *Herald* ship news department in collecting meteorological data from the logs of vessels that were making West Indian and Transatlantic voyages, I have been able to establish the connection or rather the continuation of the American zones across the Atlantic Ocean and Europe.

Some two months after the *Herald* storm predictions had begun to attract attention in Europe, the late M. Leverrier, as director of the Observatory of Paris, requested that he should be informed fully on the *Herald's* system. At the same time he expressed the greatest interest in the work, and said that he regarded it as so far successful. In reply to M. Leverrier's inquiries I addressed him a letter dated July 10, 1877, on the subject of the *Herald's* weather warnings, from which I extract the following paragraphs explanatory of the zone law of atmospheric movements:—

"From a system of observations and comparisons which the *Herald* Meteorological Department has had in operation for over two years, I have been drawn to the conclusion that instead of forming a series of detached areas of erratic movement, the high pressure encircles the earth in a number of unbroken zones, the axes of which alter in direction under the influence of inconstant conditions. Also that between these zones of high pressure lie the zones of low pressure along which the storms take their courses. The normal direction of these zones is nearly parallel with the equator, but they are sometimes so displaced by a combination of influences that their axes form an angle of forty-five degrees and over with that line. I am also satisfied that between the southern extremity of Greenland and the equator there are two zones of low, and perhaps two, but certainly one, of high pressure. The approximate axis of the zone of high pressure lies between the 30th and 45th parallels of latitude, but, as I have already stated, this direction is subject to extraordinary variations.

"The zones of high pressure are defined by the isobars of 30·0 inches, or 762mm., and their margins, as well as their axes are undulating constantly under the influence of disturbances moving along the zones of low pressure. Storm areas or depressions are invariably found within the concave curvatures of these margins, and roll, as it were, along the lines which yield before them more or less readily. I therefore call these the undulating zones of high and low pressure, because of the constant wave motion observable in their axes and margins.

"The outlines of the zones of high and low pressure are governed by the movements and development of the storm centres or depressions. When disturbances of ordinary and uniform energy succeed each other at regular intervals on the northern margin, the axis of the zone of high pressure lying between the 30th and 45th parallels approaches in alignment to a regular undulation whose general direction is almost parallel with the equator. Modifications of this condition are caused by the relative infrequency of disturbances along the southern margin of the zone. When storms of unequal energy and development occur, the northern undulations become correspondingly irregular, and these reacting on those of the southern margin produce the distortions of outline which sometimes occur. The axis of the zone of high pressure assumes a compound undulatory movement which produces extraordinary variations of the weather within the range of its influence. You will readily perceive how the direction of the course of a southern storm could be changed by the influence of a northern disturbance, and how we can account in some measure for the eccentric movements of these meteors?

"Sometimes two, or even three storm centres, will force their way into the same concavity of the northern margin of the high-pressure zone. When it occurs, the combined energy of the storms enlarges the area of the general depression, absorbs or presses away the obstructing wave of dense atmosphere, or, may be, causes it to temporarily accumulate, with its apex or crest, far into the north. Then according to the resisting power of the wave in front, the storm centre commences to ascend toward the north along a gradually diminishing gradient which has the effect of throwing it on the Norwegian coast, or of giving it a curved course that will bring it from the north-westward toward the British Isles. Hence, although a storm centre may be leaving the Newfoundland coast apparently *en route* to Ireland, it is impossible to predict where it will reach Europe unless the direction and character of the undulation of high pressure in advance of it and the general trend of the axis of the zone of high pressure are known. These can only be ascertained by a series of daily observations extending over a large area such as that of the United States and Canada on this Continent, or through your international system in Europe and Western Asia. . . .

"In the centre, or nearly so, of each wave of high pressure, there is a point where the atmosphere attains its maximum density. This point is recognised ordinarily, and, indeed, properly, as the centre of the area of highest pressure, or anti-cyclonic area. The centres of highest pressure always alternate with the centres of lowest pressure when crossing a given meridian, the air movement around the former being with the hands of the clock, while that around the latter is in the contrary direction. I find that the general movement of the wind along the southern margin of the zone of high pressure is always westward, following the undulations, while that of the northern margin is eastward, also following the wave-lines. Now, taking this fact in connection with the geographical position of the zone of highest pressure between the 30th and 45th parallels, we have on the former line a general westward movement of the wind, corresponding with the trade winds, while on the 45th parallel, and north of it for some distance, the prevailing winds are from the westward. Again, a series of observations on our Atlantic and Pacific coasts, and in the interior, go to prove beyond question that some regions such as Lower California, and the south-eastern portion of the Atlantic and Gulf States may be considered as permanently within the wave-lines of the zone of high pressure. This means that the curving of the northern and the southern margins of the zone give to these regions their prevailing winds, which, in the case of Florida and Georgia are called the 'trade-winds.' In the mid-Atlantic, north of the latitude of thirty degrees, there is another permanent area of high pressure and on the southerly side of the area are experienced the 'trade winds.' Now what are these 'trade winds' after all, but the westward flow of the air along the undulating southern margin of the zone of high pressure.

"Sometimes the zone of high pressure becomes compressed to a narrow band between two areas of low pressure, and large areas of high pressure will be formed both east and west of the narrow part of the zone. . . .

"You will naturally desire to know how we reconcile the development and movements of tropical cyclones with the foregoing statements. Although the subject is one that demands a more special treatment than it can receive from me now, I will state that, when at the period of the equinox the solar influence becomes a disturbing element in the meteorology of the equatorial zone, the alignment of the axis of the zone of high pressure becomes a compound curve, so as to present to the westerly flow of the winds and the ocean current a margin of the zone, in the hollow of whose undulations a vortex is developed. This, by cumulative energy, travels around the wave curve presented to it, and then moves away along the southern margin of the zone of high pressure toward the European coast. The cyclone that devastated Indianola and Galveston in September, 1875, passed almost in a straight line from South Carolina to Valentia, Ireland, and thence probably over Southern Sweden into Northern Russia."

To these remarks I would add that the zones of high pressure sometimes come together but do not merge, and that disturbances moving along the partly-closed zone of low pressure toward the region of contact between the two high-pressure zones, have the necessary energy to divide them again, and thus open a passage eastward between them. On the other hand, the zones close on a depression, and lift it to the higher levels of the atmosphere, where its humidity is condensed into rain that falls over a region whereon the surface-pressures are high.

With the object of utilising the zone law for the purpose of predicting the movement of storms across the oceans and continents, the meteorologist must watch the axial and marginal undulations, and be always aware of the general direction of the former. If this knowledge is possessed the prediction of storm movements becomes a simple matter of close observation and experience. To those who devote their whole attention to the work no difficulties can arise, because nature has fixed within certain degrees the limits of deviation which storm movements assume outside the normal courses for each class. The attendant conditions, such as rains, winds, variations of temperature, and humidity, and the presence of superabundant electricity are subject to greater or lesser modifications according as the storms traverse regions of land, water, mountain, or plain. I would call special attention to the appearance of storm centres over Norway and Eastern Russia, of which no serious indications of their movements were observable in the British Islands and France. Such storms occur always when the pressure is high over the countries last named, and they pass along the northern margin of the zone of high pressure north of the Hebrides or between the Faroe Islands and Iceland, and then move in a south-easterly direction with the undulation into the Baltic and the great plains of Russia, where they sometimes develop considerable energy. This is due to the operation on the eastern slopes of the Scandinavian Mountains of the same causes that combine to produce the north-western storms of Montana Territory.

It is unnecessary to refer to the local phenomena of European storms; they are so fully understood that it is impossible to add anything to the acquired information regarding them. Yet I mention them in the hope that some of the suggestions I have offered in the foregoing may be applied to the study of their development and nature. JEROME J. COLLINS

SOLAR RADIATION

Les Radiations chimiques du Soleil. Par M. R. Radau. (Paris: Gauthier-Villars, Imprimeur-Libraire, Quai des Augustins, 1877.)

THE importance of an accurate registration of the comparative intensities of solar radiation is not to be over-estimated at a time when so much diversity of opinion exists regarding the climatic effect which the sun produces upon our earth. Such radiations have been divided into three classes, the heating, the visible, and the chemical or actinic; and though the whole of these three divisions are for the most part arbitrarily defined, yet such a mode of denoting the rays of light lying between certain limits in the spectrum is on the whole convenient, if the proper mental reservation be made. In the work before us we have an account of the various researches that have been made by different physicists for obtaining a measurement of the comparative intensities of the chemical radiations. An absolute measure of their energy has, up to the present time, been found impracticable, but by noting the amount of change produced by them in what are known as sensitive compounds, a *comparison* of the otherwise immeasurably small quantity of work that they are capable of performing can be made. The amount of chemical decomposition or combination, caused by the work performed by these rays, is in reality a measure of the work performed by some previous chemical operation together with the infinitely smaller quantity, due to the energy in these radiations. All processes, therefore, which have been employed for the purposes of actinometry, give results which are comparative measures of intensity, and not of absolute energy. Perhaps the nearest approach to an attempt at a measurement of the latter was by means of the chlorine and hydrogen actinometer of Bunsen and Roscoe, certain absorption experiments with which have been well described in the work before us.

In the introductory matter are cited the comparatively recent researches of Vogel of the Berlin Industrial College, in which he shows that by the addition of certain dyes to silver bromide he is able to alter the position of maximum sensibility of this compound to the spectrum. The results of these experiments are certain, but the explanation offered is perhaps more doubtful. It may be remarked, however, that, as a rule, the dyes most effective are fluorescent, and capable of combining with silver, which may be a help in estimating the reason of the alteration. After referring to other researches of Chastaing and Berthelot, the author glances at the method of estimating the intensity of the chemical rays by the combination between chlorine and hydrogen. The feasibility of this plan was announced by Draper, in 1843, but it was only carried into practical effect by Bunsen and Roscoe, who published their first results in 1853. In 1857 Draper proposed an actinometer based on the decomposition by light of ferric oxalate into ferrous oxalate and carbonic anhydride. "Unfortunately," says the author, "Draper's process, if it leaves nothing to be desired in regard to precision and sensitiveness, is laborious in execution, and is hardly possible in practice."

A reference is also made to the use of a mixture of oxalic acid and uranium nitrate by Nièpce de St. Victor for the same purpose, with a statement that with the actinometer employed the readings were very precarious, though by improved apparatus they might be made more reliable.

Bunsen and Roscoe's actinometer, which, as before stated, depended on the combination between chlorine and hydrogen, is next fully discussed. The various experiments made to obtain a proper unit of intensity, to ascertain the absorption of rays due to the chemical operations performed by the light, and the relative effect of the different portions of the spectrum, are well worthy the attention of all workers in this branch of research.

In the next division of the book we have a *résumé* of the work done by, and the apparatus necessary for, an actinometer dependent on the darkening of silver chloride, the latest form of which was brought out by Roscoe in 1874, and is known as his automatic actinometer.

The substance of the various papers on the subject by Bunsen and Roscoe which have appeared in the *Philosophical Transactions* at different times have been condensed in a division entitled the "applications climatologiques," and very interesting it is. Thus we have an account of the measurement of the intensity of light proceeding from various parts of the sky with the sun at different altitudes; of a measurement of the intensity of direct sunlight; the effect of the height of the barometer and thermometer on the amount of chemical radiations; and of the variation of their intensity at different times of the year and at different latitudes.

In another division we have a discussion on the actinometer of Roussin dependent on the chemical reaction of nitro-prussiate of sodium and ferric chloride; of Phipson's proposal to employ molybdic acid dissolved in an excess of sulphuric acid; of Becquerel's ammonium oxalate with mercuric chloride actinometer, and also of his electro-chemical measurer; and finally we have a description of Marchand's researches, which at present have been but little known in England. We suppose it was impossible to close the subject without an article dedicated to "Light and Vegetation," which perhaps is long enough considering how little is really known of these relations.

We have been thus specific in giving the contents of Radau's little work, as it is in reality the only readily accessible account of the classical researches of Bunsen and Roscoe. The years which have been occupied in these investigations by these physicists number more than twenty, and it is doubtful if the results obtained have received all that attention from men of science which they deserve. No one who has not been engaged in similar experiments can be aware of the difficulties to be encountered in carrying them out; that they are great may be shown by the fact that no independent attempt has been made to check the results or at all events there are no published accounts of them.

The book is a compilation of the results obtained by various persons, and it would be out of place to criticise it in the same way we should if it contained original investigations made by the author. At the same time we may say that there are some few points in the various researches which are open to modification and even to correction, more particularly in those of Marchand.

BRAIN

Brain; a Journal of Neurology. April 1878. Part I. To be published quarterly. (London: Macmillan and Co.)

A NEW scientific quarterly has made its *début*, entitled *Brain*, a Journal of Neurology, edited by Dr. Bucknill, Crichton-Browne, Ferrier, and Hughlings-Jackson, names well known in connection with the physiology and pathology of the nervous system, and supported by an able staff of contributors.

According to the prospectus which has been issued, *Brain* will treat of the anatomy, physiology, pathology, and therapeutics of the nervous system, from the brain, downwards. The functions and diseases of the nervous system will be discussed, both in their physiological and psychological aspects, but mental phenomena will be treated only in correlation with their anatomical substrata, and mental disease will be investigated as far as possible by the methods applicable to nervous diseases in general. The want of such a journal has, say the editors, been long felt; and, considering the great advances which have been made of late years in the physiology of the brain and nervous system, and the great ignorance that prevails with respect to diseases of the nervous system, even among the majority of otherwise well-informed medical men, we believe the statement well founded, and anticipate a career of great usefulness to the newly-founded journal. In the first number the editors have fulfilled the greater part of their programme, which is stated to include original articles, critical digests, reviews, and abstracts of researches on the nervous system at home and abroad, correspondence on matters relating to neurology, &c. The strength of Part I. lies in its original articles. The first is by Mr. Jonathan Hutchinson, "On the Symptom-Significance of Different States of the Pupil;" the second by Mr. G. H. Lewes on "Motor-Feelings and the Muscular Sense;" the third by a French contributor, M. Duret, "On the *Rôle* of the Dura Mater and its Nerves in Cerebral Traumatism;" the fourth by Dr. Gowers, "On some Symptoms of Organic Brain Disease;" the fifth "On Brain Forcing," by Dr. Clifford Allbutt; the sixth by Dr. Bevan Lewis "On the Comparative Structure of the Cortex Cerebri;" and the seventh by Mr. Crochley Clapham, "On Skull Mapping." There are also clinical cases by Drs. Hughes Bennett, Buzzard, and Urquhart. Dr. Ferrier gives an analysis of an important memoir by Dr. Duret, "On the Mechanism of Cerebral Concussion and Compression," and Dr. Bucknill reviews severely, but not beyond its deserts, a work by Dr. Bateman, intitled "Darwinism Tested by Language," in which the main point sought to be established against Darwin and evolution is the immateriality of the faculty of speech, and its being a distinctive attribute of man.

Several shorter notices are given of recent papers and lectures relating to the brain and nervous system. These might, with advantage, have been much more numerous, and we hope to see this part of the programme more completely carried out in subsequent numbers.

The original articles would require each a separate analysis to do them justice. We content ourselves in the meantime with merely mentioning their titles. They are all worthy of attentive study, and many of a high standard of excellence, as might indeed be expected from the names of the contributors.

While the majority of the articles in *Brain* are of special interest to physiologists and medical men, they will, at the same time, prove a rich field of material for those—a rapidly increasing army—who believe that psychology is to be advanced, not merely by interrogating consciousness, but by intelligent study of the relations between body and mind, as indicated by physiological research and the phenomena of disease.

While philosophical speculation has interest but for very few of the medical profession, the facts relating to diseases of the nervous system daily observed by medical men, and reported and commented on in a journal like *Brain*, ought to prove of value to all students of the problems of physio-psychology.

We heartily wish *Brain* all success and prosperity in its career.

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.*]

The New "Oil Immersion" Object-Glass Constructed by Carl Zeiss, of Jena

By the courtesy of its manufacturer, this remarkable lens was sent me, a fortnight since, that I might carefully examine it. The results may be of interest to those who have not seen the lens: and the statement of them is due to the industry and skill of the maker.

The lens has a focal length of one-eighth of an inch: it is an "immersion," but the fluid employed is the oil of cedar wood. The object of this is that the fluid placed between the lens and the covering glass of the object, may have refractive and dispersive indices as nearly as possible coincident with those of crown glass, the material of which the covers and the front lens are composed. Ol. ligni cedri is the liquid that has been found to be most capable of meeting these conditions; and by its use the covering glass, thick or thin, and the oil and lens, become practically one homogeneous whole; and the need for the "screw collar correction" for different thicknesses of cover, is done away. At the same time, and by the same means, a large and efficient "angle of aperture" is secured. Mr. J. W. Stephenson, F.R.M.S., suggested to Prof. Abbe this method, and Prof. Abbe and Carl Zeiss have together produced the glass.

As a piece of workmanship it is extremely fine; and it can be used with quite as much ease as an ordinary immersion $\frac{1}{8}$-inch objective. It works admirably with Powell and Lealand's ordinary sub-stage condenser, with Wenham's reflex illuminator, and with the small plano-convex lens which the maker sends with it to be fastened to the under-surface of the slide with the oil of cedar wood. But I have also secured admirable results with the illuminating lens of Powell and Lealand's supplementary stage, which gives entire command over the angle of the illuminating ray.

The "spherical aberration" in this lens is beautifully corrected; the "field" being perfectly flat. The colour corrections are, so far as the lens goes, equally perfect; but are somewhat conditioned by the dispersive power of the oil, which can be modified readily, and for which Carl Zeiss provides. The sharpness and brilliance of the "definition" which this lens yields is absolutely unsurpassed, in my experience; and it has a very great power of "penetration."

I tested it with a series of "tests" with which I have proved and compared the glasses of various makers in England, the Continent, and America for some years. Up to the time of receiving this lens, the $\frac{1}{8}$-inch that had done the most in my hands, was one of the "new formula" lenses of Powell and Lealand. It is but justice to say that all my most crucial tests were equally mastered by the lens of Carl Zeiss. I have not been able to do more with it, than with the English glass, *but the same results* can be accomplished *much more readily*. The correction has to be brought into operation, and careful adjustment made, to get the finest result with the English lens; but the German glass has simply to be brought into focus, and the best result is before the observer, provided that the light has been adjusted in the most efficient manner. It is true that for sharp and perfect definition we must be careful to adjust the length of the draw-tube; in working this lens there is much need of attention to this matter; and speaking from a practical point of view, it takes the place, in securing crisp definition, of the screw-collar adjustment; although, of course, much easier of application. But it is so easy to work the lens with fine results on the more delicate tests, that I think that those who make the resolution of these their primary object in the possession of a microscope, can scarcely fail in securing their utmost desire. It is a glass pre-eminently suited for the resolution of difficult lined or beaded objects.

I have in my cabinet several frustules of *Navicula rhomboides* ("*N. crasinnervis*") which I cannot fully resolve with Powell and Lealand's new formula $\frac{1}{12}$-inch objective. But all that I *can* resolve with the English $\frac{1}{8}$ I have resolved with the German glass. *Amphipleura pellucida* is easily resolved into delicate beads when the frustules are moderately coarse; and almost any that can be met with are resolvable into lines; and this when these diatoms are mounted in balsam. And the highest eye-pieces made may be used without any practical detriment to the image; although, of course, with a reduced sharpness of the definition.

On the whole, I think it in many senses the finest lens, of its power, that I have ever seen; and in every sense it is an admirable acquisition.

But it is a fact that even water "immersion" lenses are of very limited service in observations continuously conducted upon minute *living* organisms in fluid. We may gladly call in their aid, in the determination of a delicate change of form, or in the more perfect detection and definition, of an obscure point of structure; but for steady and constant work we are bound to avoid them; for the fluid under the delicate cover is in danger every moment of being "flooded" by coming into contact with the water on the top of the cover, and between it and the lens; because the movements of the organism have to be counteracted by the movements of the mechanical stage, in order to keep any form that may be studied in view constantly. But this opens to us the possibility of going to the edge of the cover at any moment; and thus, by the mingling of the fluids, rendering the observation void. This, of course, will apply still more fully when, as in the case of the valuable glass of Zeiss, the "immersion fluid" is an essential oil.

Happily it is only in special cases that the greater analysing power, combined with larger working distance, which is possessed by immersion lenses, is required. It is in the earlier study of an organism, and before continuous work upon it has begun. And even if it be not, in the majority of cases, a first-class dry English lens of a higher magnifying power, if efficiently used, accomplishes all that is required. Hence the fine "new formula" lenses, *dry* (also provided with fronts to be used as immersion lenses), are as yet an unsurpassed boon for this special class of work. And certainly it is one which, in relation to biology, has a most important future. I know of course, that the optician has irresistible limitations to deal with; but the "new formula" dry lenses I have referred to, prove, in comparison with the preceding lenses, made by the same firm, that the dry lens was capable of most serviceable improvement. The same applies to a $\frac{1}{35}$th-inch lens, made recently at my request by the same skilful makers. As an analytical optical instrument, it is possessed of capacities far greater than are represented by its mere increase of *magnifying power over the* $\frac{1}{25}$th-inch objective, by the same makers; and equally so in relation to their $\frac{1}{50}$ths of six or seven years ago, when the superior magnifying power of the latter is considered. And yet the $\frac{1}{25}$th-inch and the $\frac{1}{50}$th-inch to which I refer, were admirable glasses, and have done excellent service. What is important, therefore, is that the larger demand for lenses that will "resolve" readily, difficult lined and beaded objects, which can certainly be best done, all things being equal, with "immersion" lenses; and to the improved manufacture of which Carl Zeiss' oil immersion gives apparently a new departure: should not lead the best opticians in England, the Continent, and America to abandon efforts for the still greater improvement of their dry lenses. They are of the greatest value to the practical biologist, working amidst the minutest living things in Nature, and from the study of which so much may be anticipated.

There is another feature in the use of this lens which is a drawback. The essential oil is a solvent of most of the varnishes and gums used in mounting, and "finishing," microscopical "slides;" and consequently some of our cherished "tests"—placed near the edge of the cover, and which we have been in the habit of using for years, will not serve us. And this, of course, has a wider application. But this may be overcome by coating the edge with shellac-varnish, which the oil does not dissolve; only this is extremely brittle, and is not to be depended on.

But it is further necessary, in using this lens, that the objects should be mounted in balsam, or some other fluid with an equal refractive index. The majority of "dry" mounted objects are by no means better shown by this lens than by an ordinary immersion lens. But this may be overcome if the objects, such as frustules of diatoms, be "burnt" on to the cover. This intimately unites the crown glass cover and the object, making them practically one. If this be not done the ray coming from the object has to enter air before passing into the lens, so neutralising the special properties of the glass. But here again the *special* objects—used, for example, as "tests"—and obtained as the result of years of careful selection, are of no avail.

But this glass will be of great value in the study of rock structures, &c., because the oil will render them transparent without special polishing; and its great working distance will in such work be a great boon.

It may perhaps be right to note that this lens, although not provided with the complex arrangement of "screw-collar adjustment," and although *only* "immersion," is higher in price than the most costly $\frac{1}{8}$th by any English maker, although the latter lens may have the screw collar correction, and be both "immersion" and dry. W. H. DALLINGER

St. James's Parsonage, Woolton, Liverpool, May 1

Science for Artists

IN NATURE, vol. xviii. p. 29, there is an article upon "Physical Science for Artists," in which one of my pictures is thus described: "No. 309. The Sunrise Gun, Castle Cornet, Guernsey—Tristram Ellis. Sky colour good; impossible colour of water under sky conditions given."

It is not usual for an artist to answer a criticism, but in this instance I do so purely upon scientific grounds. The water shown is slightly ruffled with a breeze blowing *towards* the spectator, and hence reflects a part of the sky which makes a greater angle above the horizon than the reflection makes below it. The central part of the sea would reflect that portion of the sky which is at the very top of the picture, and if the critic will kindly re-examine, he will find the colours of those parts almost identical. As the sky gets greener towards the zenith with the given kind of sunrise, the sea appears greener than the portion of the sky shown, and this effect is heightened by the strong *green local colour* of the water in the *shadows*. The sea was painted after careful consideration and study direct from nature, and remembering the breeze is nearly parallel with the line of vision, is, I think, correct. If the wind had been at right angles to this line the colour would have been quite different, and perhaps this is a matter which the writer of the article did not at the moment take into consideration. TRISTRAM ELLIS

Kensington, May 10

Time and Longitude

THERE is a practical answer to the problem put by Mr. Latimer Clark (NATURE, vol. xviii. p. 40). As a matter of fact the day begins, or rather the day is first named at the 180° meridian east or west from Greenwich; but this initial line, if I may call it so, diverges in the South Pacific to about 170° west from Greenwich, bringing many of the islands, as Fiji, Friendly, Sunday, Chatham, &c., into the same date with the nearest civilisation, Australia and New Zealand, Asia, &c. Without notes I cannot trace this line accurately between the Isles, but to take certain cases. Fiji counts its day east from Greenwich, Hawaii and Society west from Greenwich. At this moment I forget which division the Navigators enter, so to answer the problem, Where did last Monday begin?—At about 170° west longitude. Where did it end?—At 180° west in North Pacific. How long did it exist?—At any one place twenty-four hours, but taking adjacent places on either side of the initial line, Monday will have been a date during forty-eight hours; or if a vessel should be just on the eastern side of the 180° meridian, and keeping, as she should, Greenwich time through American route, Monday will have been a date during very nearly forty-nine hours.

The case proposed by Mr. Latimer Clark is no hypothetical one. During the war of 1855 the squadron in the Pacific was sent across to co-operate with the fleet in China. It found itself a day behind the China fleet as it had entered the Pacific round Cape Horn, whilst the China fleet had passed round the Cape of Good Hope, and for a short time the two fleets side by side kept different days. Again the steamers from San Francisco to Japan alter their dates temporarily whilst in Japan to suit the local reckoning, and enter both dates in the log. J. P. MACLEAR

May 13

Menziesia Cærulea

I AM rather surprised to see it stated by the Rev. M. J. Berkeley in NATURE (vol. xviii. p. 15) that the late "Dr. Thomas Thomson was so fortunate, after three times ascending the Sow of Atholl, as to *rediscover the long lost Menziesia cærulea*." I doubt if it was ever lost, certainly it has not been long lost. I find, on looking over my Herbarium, that my specimen was collected August 6, 1867; since then I have heard of it having been found by others. I saw several plants which I left, and I have little doubt that some of them are there still. Fortunately the preservation of the plant is due to the following circumstances:—1st. That it flowers in May; few botanists visit the Highlands till later in the year. 2nd. The plant has a considerable general resemblance to *Empetrum nigrum*. I have seen them growing in the *same tuft*; in such a case it requires a very sharp eye to distinguish one from the other even at a short distance. 3. The plants are *widely scattered* over the hill, so that it would require days to enable any one to say that it was lost; indeed no plant is likely to be lost so long as the natural conditions remain unchanged. It may be stolen but not lost. I take for granted, of course, that every true botanist will be merciful in such a case.

Edinburgh, May 6 ALEX. CRAIG CHRISTIE

"Hermetically Sealed"

WHAT is hermetic sealing? I have been under the belief that it means sealing with the material composing the object to be sealed; as in the case of sealing a glass tube in the spirit-lamp. M. Bordier's charming paper on the Greenland Eskimo (NATURE, vol. xviii. p. 16), says that an aperture in a hut is hermetically sealed with goldbeater's skin; and that a fisherman is hermetically enveloped round the loins by a leathern bag. You may, perhaps, think it worth while, in the interest of accurate scientific terminology, to settle the point. W. T.

May 10

The Structure of Coryphodon

I OBSERVE in your issue (vol. xvii. p. 340) a note by Prof. O. C. Marsh stating that I have included in the cast of the olfactory lobes of the brain of *Coryphodon* that of a part of the nasal cavity also. Prof. Marsh fails to point out the qualifying remarks to be found in my descriptions. In the explanation of Plate I. of the *Proceedings* of the American Philosophical Society, 1877, p. 620, I say, "The right bulbus of the olfactory lobe is too large above, owing to the want of preservation of the superior wall of the cavity." In my quarto report to Lieut. G. M. Wheeler in Vol. IV. p. 223 of his Report to the Chief of Engineers, I remark, "In excavating the matrix from the Olfactory chambers some difficulty was experienced in attempting to lay bare the superior and inferior walls, &c. On one side of the bulb this boundary was probably passed through, giving a larger vertical diameter than the true one."

Philadelphia, March 23 E. D. COPE

[Prof. Cope adds other remarks on this subject and on other questions in dispute between himself and Prof. Marsh, which our space will not permit us to reproduce.—ED.]

Lightning Phenomenon

ON observing the lightning on Friday evening I noticed that several of the brighter flashes were preceded by one, or sometimes two smaller flashes, the large flash following immediately after and taking the same course as the smaller ones. I should be glad to know if any of your readers observed this, and also how it is accounted for. H. J. STAPLES

Clifton College

Secondary Lunar Rainbow

AT an early hour this morning I had the good fortune to witness a phenomenon which is of somewhat rare occurrence.

Soon after 12.15 A.M., at which time I was burning the midnight oil, by a curious coincidence, over spectrum analysis, I was roused from my books by the pattering of rain outside the open windows; upon looking up I perceived that the moon was shining brightly, and naturally concluded that as it was not very far above the horizon there must be a rainbow.

I rushed over to the opposite side of the "quad." and was rewarded for my wetting by the appearance of a most magnificent bow, in which the colours were easily distinguishable on the dark background of clouds. To complete the phenomenon and to render it remarkable, there was also a perfect secondary arc.

The primary bow lasted in great brilliance for more than ten minutes, and thus I was enabled to rouse some of our men to see it, but it vanished with the punctuality of a creation of a fairy tale, immediately the clock tolled the half-hour. Soon after its disappearance the clouds were dispersed and the heavens studded with stars. W. J. NOBLE

Keble College, Oxford, May 12

OUR ASTRONOMICAL COLUMN

THE REAPPEARANCE OF TEMPEL'S COMET, 1873, II.—The *Bulletin International* of the Observatory of Paris for May 7, contains the elements of this comet for the return to perihelion in the present year, as determined by M. Leopold Schulhof from a complete discussion of the observations in 1873, and the application of the perturbations up to the next perihelion passage. Expressed in a form slightly modified from that adopted in the *Bulletin*, the elements are as follow:—

Perihelion passage, 1878, September 1·4961 G.M.T.

Longitude of perihelion	306° 7′ 2″	Mean Eq. 1878·0.
,, ,, ascending node ...	120 59 41	
Inclination of the orbit	12 45 34	
Eccentricity	0·552895	
Log. semi-axis major	0·476478	
Mean daily sidereal motion	684″·3689	

Motion—direct.

It will be remarked that the date of perihelion passage given by M. Schulhof's investigation is considerably later than was assumed in a former note in this column, from the best calculation of elements at the last appearance then available, and we believe it is yet open to material uncertainty. The recovery of the comet at this return may therefore involve a very close search with instruments of great optical capacity, but as it may, and very probably will be within reach when the moon is again below the horizon in the evenings, it may be hoped that no time will be lost in commencing a strict examination of the track of sky on which its orbit must be projected at different dates. The following positions are extracted from M. Schulhof's ephemeris:—

12h. Paris M.T.	Right Ascension. h. m. s.	Declination. ° ′	Distance from earth.	Intensity of light.
May 18	15 59 16	+ 6 32	0·779	0·54
,, 20	15 57 34	6 39	—	—
,, 22	15 55 49	6 45	0·755	0·59
,, 24	15 54 0	6 49	—	—
,, 26	15 52 9	6 50	0·734	0·65
,, 28	15 50 16	6 49	—	—
,, 30	15 48 22	6 47	0·715	0·70
June 1	15 46 29	6 43	—	—
,, 3	15 44 38	+ 6 36	0·700	0·75

The intensity of light at the date of the last observation of the comet in 1873, which was made at Mr. Bishop's Observatory, Twickenham, on October 20, was 0·385. At this time the comet was the *extremum visibile* with a 7-inch refractor. It may appear strange that observations should not have been made at a later period with the more powerful instruments available in many of the European observatories, but it does not always occur that the largest telescopes show decided advantage over much smaller ones in following up faint comets. With the same refractor De Vico's comet of short period of 1844 was distinctly visible on December 31 in that year, which is the date of the last observation at Pulkowa, and but for the intervention of clouds, observations would have been possible. Nevertheless neither object could have been detected, in all probability, if the positions had not been pretty accurately known, and thus the recovery of a faint periodical comet when it first comes within reach, subject as the calculated places may be to material error, is a very different matter to distinguishing a faint object when we know exactly where to look for it.

On this, the first return, of Tempel's comet of 1873 since its periodicity was discovered, the date of perihelion passage upon which the geocentric path depends may reasonably be expected to be several days in error, although not necessarily so. The following would be the variations in right ascension and declination on May 18 and 30, caused by assuming the perihelion passage to occur four days earlier or four days later than the time calculated by M. Schulhof:—

	P.P. four days earlier. R.A. m.	Decl. ′	P.P. four days later. R.A. m.	Decl. ′
May 18	+ 16·7	− 50	− 15·9	+ 48
,, 30	+ 17·9	− 45	− 16·7	+ 43

This comet was discovered on the night of July 3, 1873, by M. Tempel, at the Observatory of Milan, in the constellation Cetus. Its short period of revolution was pointed out about the same time by M. Schulhof and Mr. Hind, from the observations made in July. At aphelion it approaches the orbit of Jupiter within 0·64, and in about 309° heliocentric longitude is within 0·052 of the orbit of Mars.

OCCULTATION OF MARS.—On the evening of June 3 Mars will be occulted by the moon, and no other occultation of a bright planet, visible here, will take place for several years, until 1882 or later. At the Royal Observatory, Greenwich, the immersion will occur, according to the tables, at 10h. 1m. 9s., and the emersion at 10h. 42m. 49s., mean times, the angle at emersion counted as in the *Nautical Almanac* for inverted image being 288°.

If we apply to this case the method for distributing predictions over a certain extent of country, founding our calculation upon Greenwich, Edinburgh, and Dublin, we shall find the following expressions for the determinations of the Greenwich times of immersion and emersion for any place within or not far beyond this area. M is the longitude from Greenwich, in minutes of time, + if E., − if W., and the latitude of the place is put $= 50° + L$.

		h. m.	m.	m.
G.M.T. of immersion =	June 3,	10 3·50	− 1·60 L	− 0·151 M
G.M.T. of emersion =	,,	10 44·40	− 1·07 L	− 0·114 M
The angle at emersion is	...	288°·9	− 0·74 L	− 0·12 M

As an example, suppose the times are required for Liverpool, longitude 12m. 17s. West, latitude 53° 24′.

$$L = + 3·4. \qquad M = - 12·28.$$

$$- 1·60 \times 3·4 = - 5·44\text{m}.$$

$$- 0·151 \times (- 12·28) = + 1·85\text{m}.$$

Therefore time of immersion = 10h. 3·50m. − 3·59m. = 9h. 59·91m. or 9h. 59m. 55s. G.M.T. at Liverpool.

Similarly, the time of emersion will be found to be 10h. 44·40m. − 2·29m. or 10h. 42m. 7s. G.M.T., and the angle at emersion is 288°.

GEOGRAPHICAL NOTES

AFTER the results of the last English Arctic Expedition, and the criticism with which it met on its unexpected return, one would have thought that Arctic exploration in the old lines had become a thing of the past, or at least that it would only be carried on in a very much modified form, after the method, say, proposed by Lieut. Weyprecht. On the contrary, the desire to reach the Pole has become, apparently, keener than ever. There is every reason to believe that Capt. Howgate's scheme, to found a colony of Polar knights at Lady Franklin Bay, will be approved of by the U.S. Congress. Mr. Gordon Bennett, whose zeal for the promotion of knowledge is happily not short-lived, is to send out the *Pandora* by the Spitzbergen route on a similar quest, and it is rumoured that Mr. Stanley is to lead the forlorn hope. Prof. Nordenskjöld takes up the task laid down as hopeless 300 years ago, of finding a north-east passage; and last, but really first in point of time, a little Dutch expedition left Ymuiden on the 6th inst. for a six months' Arctic cruise. Since the stirring times of William Barentz, the Dutch have had much to do to keep their heads above water, but now that they have got well out of difficulties, it is gratifying to find that they are turning their attention in a direction in which long ago they won much glory and did good service. The appropriate name of the little schooner of eighty tons, in which the expedition sailed is the *Willem Barentz*. The expedition is commanded by the Dutch naval officer, J. J. de Bruyne, with Lieutenants L. R. Koolemans Beynen and H. M. Speelman, second and third in command, accompanied by a small corps of scientific experts and a crew of eight men, fourteen all told. The first point which the expedition purposes visiting will be Jan Mayen Land, next steering its course for the north-west coast of Spitzbergen to Amsterdam Island, examining the edge of the west ice *en route*. Smeerenburg, in this island, was the principal seat of operations of the Dutch Northern Company, and some days will be spent here in looking out and marking the graves of Dutchmen, several of whom died on the island when in the service of the Company in the winters of 1633-34 and 1634-35. It is expected that about July 15 the expedition will proceed to Novaya Zemlya, probably calling at Bear Island, and, after restoring the Dutch landmarks at these various points, will attempt to penetrate as far as possible to the north-west from the coast of Novaya Zemlya at the latest period of the navigable season, returning home before the winter. The expedition on which the *Willem Barentz* sails is purely national, having been organised exclusively by means of the voluntary contributions of the Dutch. The *Willem Barentz* has been specially constructed at Amsterdam for the service, and fitted with all the modern appliances of an Arctic ship. An English photographer, Mr. W. J. A. Grant, accompanies the expedition. Every opportunity possible will be availed of by the expedition to make observations in magnetism, meteorology, zoology, and natural history, together with deep-sea soundings, and the ascertaining of the direction and force of the currents in the Barentz Sea and surrounding waters. None of the four expeditions we have spoken of will be watched with more kindly interest than that in the *Willem Barentz*.

THE Malay Peninsula, from Wellesley Province to Singapore, contains, according to a communication addressed by an experienced tea-planter to a Straits paper, millions of acres of low, undulating, thickly-wooded hills, which are well suited for the growth of tea, as the soil of which they are composed is similar to the best tea soils of India. The variety to be planted must, however, it would seem, be that indigenous in Assam. The land referred to is, indeed, only suited to the cultivation of tea or coffee, and with cheap land, plentiful labour, regular seasons, and easy transport, the Malay Peninsula would certainly appear to possess unequalled advantages for the production of tea. The soil of Singapore has been, until recently, much underrated, but it has been shown conclusively that pepper, tapioca, and sugar can be successfully grown upon it, and it is probable that the tea-shrub, which is a hardy plant, can be grown on the island as well as on the peninsula.

OUR sources of information respecting Corea and its inhabitants are very limited in number, but now and again we glean some news thereof through the Japanese, and from a letter which the *North China Herald* annually receives from a correspondent at Newchwang in Southern Manchuria. By these means we learn that the porcelain of the country is very fine; palm-leaf fans are ornamented with paintings, in various colours, of human figures and landscapes; cotton-stuffs are made like that which comes from Mikawa in Japan, and the silk is like *pongee*, but is produced in small quantities; the only coin in use is not round, but consists of pieces of rod-iron, some four inches long, and bent into a curve. Game both large and small, abounds in the country; the hills are covered with pheasants; fallow and other deer are met with everywhere; bears are numerous, especially in the lofty mountains in the north; and spotted and striped tigers have proved themselves very dangerous of late years. Strange to say, notwithstanding the number of tigers in the mountains, the Corean houses have very primitive doors, a framework pasted over with paper being their only protection.

THE latest intelligence from Senegal notifies the arrival of Lieut. Semellé, head of the French expedition for crossing Africa eastwards. M. Paul Soleillet, already known as a Saharan explorer, has also gone to St. Louis for the purpose of leading an expedition by way of Timbuctoo, and In Çalah, to Algeria, the purpose being to divert as much of the Saharan trade as possible to Algeria. These, with the hopeful expedition under Abbé Debaize, which is to cross the continent from Zanzibar, show that the French are taking a fair share in African exploration.

SIGNOR GESSI and Signor Matteucci, the Italian explorers in Central Africa, encountering unexpected difficulties between Fadasi and Kaffa, have been obliged to return to Khartoum.

THE Geographical Society of Marseilles is preparing an interesting exhibit in the Paris Exhibition. The principal portion is devoted to African products and contains 216 specimens of the leading objects of commerce derived from this continent. They are gathered together in a section surmounted by the portraits of Cameron, Livingstone, and Stanley. A large ethnographical collection of weapons, utensils, etc., completes the exhibit.

PHYSICAL PROPERTIES OF METALS[1]

ONE of the most characteristic properties of metals is the power possessed by them when in more or less compact masses of acquiring (by polishing, pressure, or other mechanical treatment) such a condition of surface that light incident thereon is for the most part again reflected, whereby a peculiar glistening appearance is presented, known as the *metallic lustre*.

Owing to the influence of the air, moisture, vapours arising from putrefaction, &c., metallic surfaces, even when highly polished and brilliant, become more or less

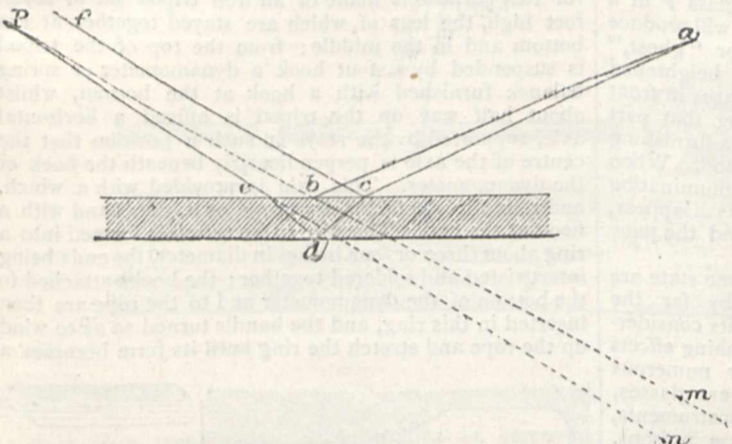

FIG. 1.

rapidly tarnished, so that the power of reflecting light is to a considerable extent lost. Before the invention of glass polished metallic surfaces were employed as *mirrors;* and for reflecting telescopes such surfaces are still in use. Now, however, it is usual to employ as mirrors glass surfaces behind which a thin coating of some lustrous metallic mass is placed, so that the smooth surface of the glass at once determines the peculiar reflective power of the metal applied to it, and preserves the metal from mechanical injury and from the corrosion of the air. For this reason these household appliances

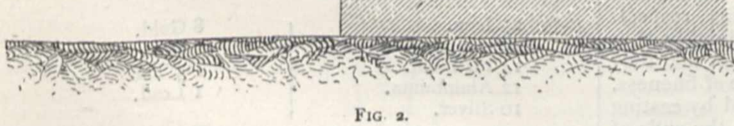

FIG. 2.

are ordinarily termed "looking-glasses," although strictly speaking it is not the glass that is the essential part.

Three principal methods of applying these metallic substances to glass are in use; the best plate-glass mirrors (perfectly plain surfaces) are prepared by spreading out on a table surrounded with a deep groove or gutter, and capable of being raised on hinges so as to be placed at any angle with the horizon, a sheet of tinfoil, and smoothing it with a soft brush; mercury is then poured on and gently rubbed over the tinfoil with a hare's foot or a roll of flannel so as to penetrate and brighten the tin; more mercury is then poured on, and the surface cleansed from dross, &c.; finally, the perfectly clean sheet of glass is dexterously slid over the brilliant mercurial surface in such a way as to avoid inclosing any particles of dust or air-bubbles between the metal and glass. The table is then slightly raised at one end, so that the surplus mercury may gradually run off and be caught in the gutter; and the slope is increased daily, a piece of flannel being placed on the glass with weights on it to facilitate the draining off of the mercury. After two to four weeks, according to the size of the plate, the mirror is complete, the tin amalgam having then completely set, and being tolerably firmly adherent to the glass, although easily rubbed off and scratched on account of its slight tenacity. To preserve the back of the mirror from injury a suitable wooden frame is provided, in which the whole is fixed, when a finished mirror is the result.

For curved surfaces, such as the insides of globes, flasks, &c., for ornamental purposes, a somewhat different plan is employed: a fluid or semi-fluid amalgam capable of adhering to glass is poured into the vessel to be "silvered," and shaken about therein until the inner surface is covered with a film of the composition; the surplus amalgam is then poured out and used for other similar objects. A mixture of one part each of lead, tin, and bismuth, with two parts of mercury, answers well, the mixture being made perfectly fluid by slightly warming it before pouring into the vessel to be silvered.

A method which has of late years come largely into use for silvering mirrors of various kinds, and notably the reflectors of telescopes and lighthouses, is based on the power of certain chemical reagents to throw down silver in the metallic state from certain of its solutions, &c., the reduced silver in many cases adhering firmly to the surface of the vessel in which the action takes place, or to objects immersed in the liquid. Thus, if calcium tartrate in a moist state be placed in a glass vessel with a crystal of silver nitrate and a drop of ammonia solution, and the mixture cautiously heated, and made to flow successively over the whole inner surface of the glass, a fine mirror may be developed. Aldehyde, oil of cloves, and other essential oils, grape-sugar, and some other organic substances, may also be employed as reducing agents, especially the first substance.

If a "mirror" (*i.e.*, a glass surface with a brilliant metallic film behind) be carefully examined, it will be found that in most positions it will give a double image of any object reflected, one image being usually more brilliant than the other. Fig. 1 illustrates how this is brought about; a ray of light from an object at *a*, strikes the glass surface at *b*, and is reflected to the eye of the observer at P, so that an image is seen situated at *m*. Another ray of light incident on the glass at a point *c*, is partly reflected along *c f*, this portion of the ray consequently never reaching the eye at P at all; the rest of the ray enters the glass, being refracted along *c d;* at the junction of the glass and metallic surfaces reflection takes place along *d e*, and at *e* the ray is refracted along *e* P, thus also reaching the eye of the observer, but

[1] From a forthcoming volume of the NATURE Series—"Metals and their Chief Industrial Applications. Being, with some Considerable Additions, the Substance of a Course of Lectures Delivered at the Royal Institution of Great Britain in 1877." By Charles R. Alder Wright, D.Sc., &c., Lecturer on Chemistry in St. Mary's Hospital Medical School. (London: Macmillan and Co., 1878.)

necessarily causing the image formed to be seen apparently situated at *n*, a point different from *m*. The relative quantities of light passing along *e* P and *b* P (that is, the relative brightnesses of the two images) depend on the degree of obliquity of the incident light *c*; the greater the angle *a b* P (*i.e.*, the more obliquely the light falls on the mirror), the brighter is the image at *n*. The power of glass thus to reflect light to a considerable extent without any metallic film behind is utilised in the illusion known popularly as "Pepper's ghost," which consists simply of a large pane of glass sloping forwards from the stage at an angle of about 45° (Fig. 2). Objects such as A B, placed between the footlights E, and the pane of glass F in a horizontal position, and strongly illuminated, will produce to a spectator in front at P, a virtual image or "ghost," apparently situated at C D, the illusion being heightened by hiding, by means of screens, all the apparatus in front of the pane from the audience, and darkening that part of the stage behind the pane, the real objects furnishing the ghosts being placed on a dead black ground. When the lights E are extinguished, and other lights illuminating the stage behind the pane turned on, the ghosts disappear, whilst the real actors at D C on the stage behind the pane become visible *through* the transparent glass.

Most of the metals used in the arts in the free state are of considerable density, aluminium being by far the lightest, a circumstance which, together with its considerable strength and power of resisting the tarnishing effects of the air, renders it peculiarly suitable for numerous purposes: the draw-tubes of telescopes, opera-glasses, &c., and the graduated circles of surveying-instruments, &c., are often made of this metal for these reasons. According to the way in which a piece of metal has been obtained, its density will vary somewhat, being increased by hammering or any mechanical action which forces the particles together, *e.g.*, wire-drawing or sheet-rolling. The following table gives the numerical values of the average densities of most of the more important metals:—

Specific Gravity of Metals (*Water* = 1).

Platinum	21·5	Iron	7·8
Gold	19·3	Tin	7·3
Mercury	13·6	Zinc	7·1
Palladium	11·8	Antimony	6·7
Lead	11·3	Arsenic	5·6
Silver	10·6	Aluminium	2·6
Bismuth	9·8	Magnesium	1·8
Copper	8·9	Sodium	0·97
Nickel	8·8	Potassium	0·86
Cadmium	8·7	Lithium	0·59

Although the property of being drawn into wire is closely allied to that of being rolled or hammered into foil and leaves, yet the two are not necessarily possessed to equal extents by the same metal; gold, silver, and platinum are pre-eminently "ductile," whilst copper and iron are but little inferior to them in this respect. Aluminium and zinc can be obtained in tolerably thin wire, whilst lead and tin have so little cohesion that they cannot be drawn beyond a very limited degree of fineness. On the small scale, wires are readily obtained by casting the metals into thin pencils,[1] slightly pointing the ends of these and passing them into a funnel-shaped hole in a steel plate (*draw-plate*) of suitable size, gripping with pliers the protruding pointed part, and forcibly pulling the whole bar through the hole, the process being then repeated with a slightly smaller hole.

In drawing wire on a manufacturing scale, the process is just the same in principle, only, instead of drawing the wire through the draw-plate by hand by means of a wheel and axle, &c., the wire is pulled through by hand with pliers for a foot or two, and this portion then fastened to a revolving drum which then pulls the rest of the wire through, coiling up the drawn-out portion on the drum; the wire is then passed through the next smaller hole, being uncoiled from the first drum, and coiled again on a second in so doing, and so on until drawn to the required degree of fineness. In this way great lengths of wire are drawn at one operation.

By forming metals into wires of equal dimensions, and then determining the weight requisite to break these wires, the differences in tenacity exhibited by metals and alloys may be readily demonstrated. A convenient apparatus for this purpose is made of an iron tripod six or seven feet high, the legs of which are stayed together at the bottom and in the middle; from the top of the tripod is suspended by a stout hook a dynamometer or spring balance furnished with a hook at the bottom, whilst about half way up the tripod is affixed a horizontal axle, supported by the stays in such a position that the centre of the axle is perpendicularly beneath the hook of the dynamometer. This axle is provided with a winch, and round it is coiled a stout rope or leather band with a hook at the end. The wire to be tested is formed into a ring about three or four inches in diameter, the ends being intertwisted and soldered together; the hooks attached to the bottom of the dynamometer and to the rope are then inserted in this ring, and the handle turned so as to wind up the rope and stretch the ring until its form becomes a narrow oblong. The tension is then increased by winding the rope until the wire breaks; the reading of the dynamometer is noted by an assistant at the moment of rupture.

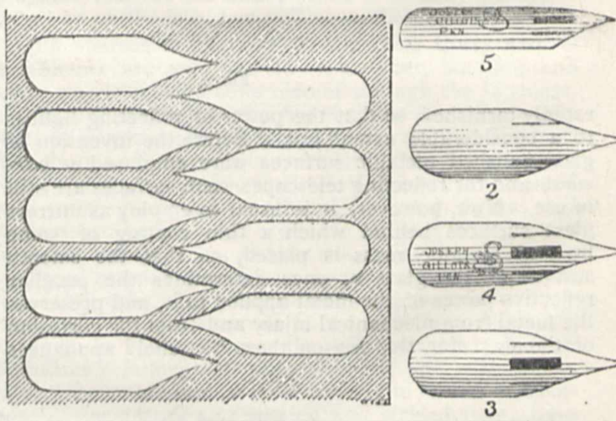

FIG. 3.

In this kind of way the order of tenacity of the metals is found to be as follows:

25 Iron.	8 Gold.
16 Copper.	7 Zinc.
14 Platinum.	1·5 Tin.
12 Aluminium.	1 Lead.
10 Silver.	

Closely connected with the physical structure which enables metals to exhibit the phenomena of crystallisation, malleability, and ductility, is the power which some possess of returning to their original shape when deflected therefrom by some external force not too great (*elasticity*); a property possessed to an extreme degree by good steel. The operations of wire-drawing, rolling, hammering, and the like generally increase the elasticity of metals, whilst annealing and fusing usually diminish it. Some metals are almost wholly devoid of elasticity; thus lead scarcely exhibits a trace of this property, being so soft that it is readily abraded by the nail. Some metals and alloys, when worked into appropriate shapes and struck, continue vibrating for some time, and hence are powerfully

[1] For metals of moderately-low melting-points the fused substance may be drawn up into a hot thin glass tube or pipe-stem by suction, and allowed to solidify therein. By fusing the metal in the bowl of a tobacco-pipe and tilting this so that the stem is inclined downwards, the molten metal can often be made to form a rough wire or thin rod in the stem readily obtainable by breaking away the pipeclay after cooling.

sonorous (*e.g.*, aluminium, bell metal, steel, standard gold, &c.).

The chief value of many metals and alloys for industrial purposes lies in their possession to a greater or less

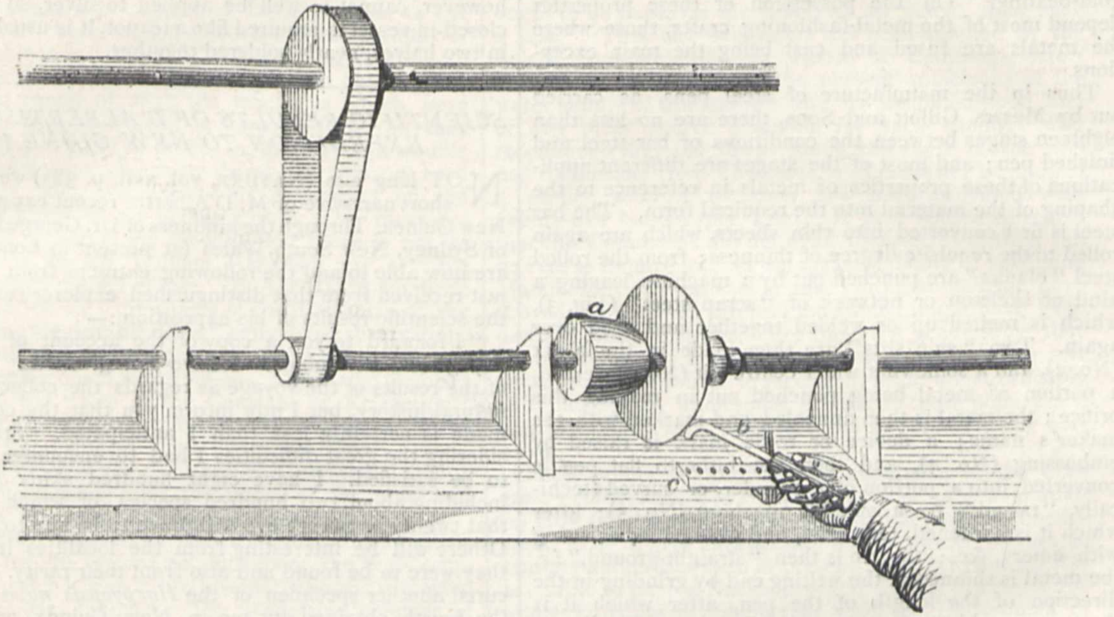

Fig. 4.

extent of a combination of properties of somewhat

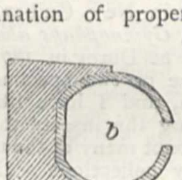

Fig. 5.

opposite kinds; whilst they possess sufficient rigidity to keep their shape even with moderately hard usage and to bear "wear and tear," when once fashioned into articles of domestic and everyday use, they have the power of yielding to pressure, &c., to a sufficient extent to enable them to be readily worked into these forms. In some cases the requisite softness for this latter purpose is hardly attained until the temperature is considerably raised; thus most articles of wrought iron are made when the metal is softened by heat so as to yield readily to percussion (*forging*) and other shaping processes. Closely connected with this softening or incipient conversion into a pliable mass by heat, is the phenomenon of *welding*, or

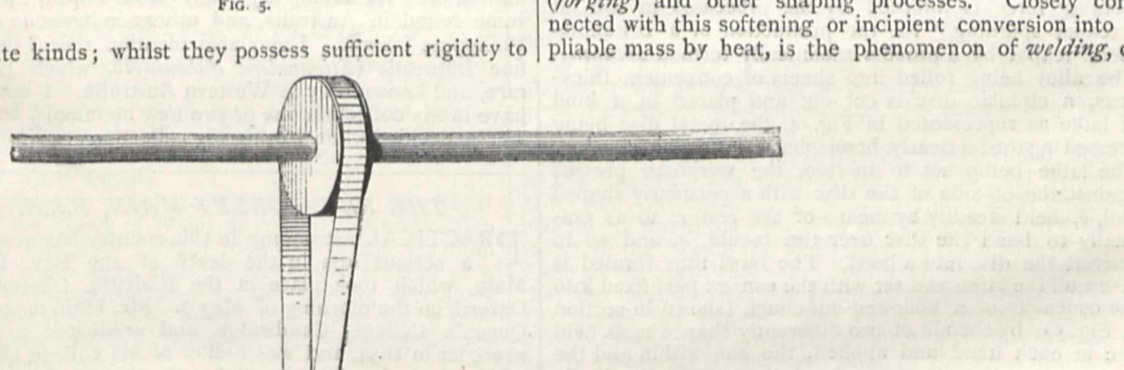

Fig. 6.

the adherence together of two separate metallic masses when united by pressure in such a way as to form a join as strong as the other parts. Iron and platinum possess this power at a high temperature; sodium and some of the rarer metals at the ordinary temperature; gold also can be welded cold, under certain conditions, as in gold-beating. On the possession of these properties depend most of the metal-fashioning crafts, those where the metals are fused and cast being the main exceptions.

Thus in the manufacture of steel pens, as carried out by Messrs. Gillott and Sons, there are no less than eighteen stages between the conditions of bar steel and finished pen; and most of the stages are different applications of these properties of metals in reference to the shaping of the material into the required form. The bar steel is first converted into thin sheets, which are again rolled to the requisite degree of thinness; from the rolled steel "blanks" are punched out by a machine, leaving a kind of skeleton or network of "scrap steel" (Fig. 3), which is melted up or welded together and used over again. Two "side slits" are then made in the blank (No. 2), and a somewhat wider centre slit (No. 3) pierced, a portion of metal being punched out in making this orifice; the metal is then annealed and marked with the maker's name; a device or trade mark is raised by embossing (No. 4), and then the hitherto flat pen is converted into a portion of a cylinder, or curved (techically, "raised") by a suitable machine (No. 5); after which it is hardened, tempered, and cleaned by scouring with emery, &c.; the tip is then "straight-ground," *i.e.* the metal is thinned at the writing end by grinding in the direction of the length of the pen, after which it is "cross-ground," in the transverse direction. Finally the slit from the nib to the punched-out central part is cut, and the pen is coloured and varnished for sale.

Again, the manufacture of table-spoons and forks, many kinds of brass-work, cutlery, percussion-caps, copper pans and kettles, medals, and coins, and a thousand-and-one articles of every-day use, all depend upon the possibility of forcing the metal into various shapes without fracturing it, by mechanical processes, such as forging, punching, pressing, embossing, and the like. One of the prettiest illustrations of the application of pressing and shaping force is afforded by the processes in use for "teapot spinning," *i.e.* the production of a Britannia-metal teapot by a process technically termed *spinning*. The alloy being rolled into sheets of convenient thickness, a circular disc is cut out and placed in a kind of lathe as represented in Fig. 4, the metal disc being pressed against a nearly hemispherical wooden chuck *a*. The lathe being set in motion, the workman presses against the off-side of the disc with a peculiarly shaped tool, *b*, held steadily by means of the rest, *c*, so as gradually to bend the disc over the mould, *a*, and so to convert the disc into a bowl. The bowl thus formed is taken off the lathe and set with the convex part fixed into the concavity of a hollowed-out chuck (shown in section *a*, Fig. 5); by the aid of two differently shaped tools held one in each hand and applied, the one within and the other without the rim of the bowl, the metal is gradually bent inwards as it revolves, so as finally to take an almost globular shape: Fig. 6 indicates the closing stage of this operation, the nearly globular bowl thus formed being shown in section in Fig. 5 *b*. Finally the lid, spout, handle, &c., are attached, and the whole brightened and polished for the market. During the spinning the edge of the disc, some forty or fifty inches in circumference, becomes diminished to almost half that in the bowl, and to about one-quarter in the globular pot, the metal being thus as it were pressed in upon itself, as well as somewhat extended, the superficial area of the outside of the globular pot being somewhat greater than that of one side of the circular disc used in the first instance. In a similar fashion jugs and analagous vessels are "spun up," out of plates, the lips for pouring being subsequently shaped by carefully hammering or pressing out the metal on a wooden or metal mould. Silver articles, *e.g.*, bowls, teapots, &c., are frequently curved by an analogous operation; the second stage, however, cannot so well be applied to silver, so that if a closed-in vessel is required like a teapot, it is usually made in two halves, neatly soldered together.

SCIENTIFIC RESULTS OF D'ALBERTIS' LAST EXPEDITION TO NEW GUINEA

NOT long ago (NATURE, vol. xvii. p. 383) we gave a short narrative of M. D'Albertis' recent expedition to New Guinea. Through the kindness of Dr. George Bennett, of Sydney, New South Wales (at present in London) we are now able to add the following extracts from a letter just received from that distinguished explorer respecting the scientific results of his expedition :—

"I forward to you a copy of the account of my last voyage to New Guinea. I have not given any account of the results of the voyage as regards the collections of natural history, but I now inform you that the collection made is certainly less than I anticipated. Still, considering the great difficulties I had to encounter I ought to be satisfied. I have eight hundred skins of birds, including about two hundred species, of which I hope that twenty or twenty-five will prove to be new to science. Others will be interesting from the localities in which they were to be found and also from their rarity. I procured another specimen of the *Harpyopsis nova guinea*, the fourth obtained by me in New Guinea, and it is certainly remarkable that it has never been obtained by any other traveller in New Guinea. I also found the rare ground-pigeon, *Gymnophaps albertisi*, which I had previously obtained at Dorey in 1872, but it is so rare there that only one or two specimens were found by Beccari and Bruijn, and I have likewise two or three new parrots. Among the insects there are many very beautiful, and no doubt many of them will be new. The examination of my collections will be interesting to naturalists as showing the capricious distribution of animal life; for among my beetles from Papua, there are some found in Australia, and others indigenous to the Philippine Islands. I may also mention that I found a fine Buprestis (*Stigmodera duboulayi*), which is very rare, and known only in Western Australia. I may also have in my collection one or two new mammals, but this will be decided when I bring my collections to Europe."

THE REV. ROBERT MAIN, F.R.S.

PRACTICAL astronomy in this country has sustained a serious loss in the death of the Rev. Robert Main, which took place at the Radcliffe Observatory, Oxford, on the morning of May 7. Mr. Main entered at Queen's College, Cambridge, and graduated as sixth wrangler in 1834, and was Fellow of his college 1836-38, taking clerical orders in 1836. On the appointment of the present Astronomer-Royal he was selected to fill the office of First Assistant in the Royal Observatory, Greenwich, which position he retained, until, on the death of Mr. Johnson, he was appointed, in June, 1860, to the direction of the Radcliffe Observatory. During his connection with the Royal Observatory he was a frequent contributor to the *Memoirs* of the Royal Astronomical Society, his first paper "On the Node and Inclination of the Orbit of Venus" having been presented in June, 1837. This was followed by memoirs "On the Correction of the Mean Distance, Eccentricity, Epoch, and Longitude of the Aphelion of the Orbit of Venus," and he returned to the same subject in two subsequent communications read April 13 and December 14, 1838. In May, 1840, Mr. Main contributed a paper on "The Present State of our Knowledge of the Parallax of the Fixed Stars," which was of much value at the time, as presenting a condensed criticism of all that had been effected in this direction; this paper was originally read to the council, in support of Bessel's claim to the gold medal for "his assumed discovery of the parallax of the remarkable star 61 Cygni." In 1845 Mr. Main procured the reduction of the numerous sextant observations of the great comet of 1843, the results of which were presented in a memoir read in January, 1846; but they did not justify, in point of precision, the time and trouble which had been expended upon them. In a paper read March, 1849, Mr. Main gave his deductions on the ellipticity and form of the planet Saturn, from measures at the Royal Observatory, showing that there is not, as was suspected by Sir William Herschel, any sensible deviation from a perfect ellipse. In April, 1856, he made a communication on "the values of the diameters of the planets having measurable discs," embodying observations with a double-image micrometer, extending from 1840 to 1852. His subsequent contributions to the same memoirs are (1) "On the Value of the Constant of Refraction" (1857), (2) "On the Proper Motions of the Stars of the Greenwich Catalogue of 1576 Stars for 1850" (1858), (3) "On the Value of the Constant of Aberration" (1860). Mr. Main successively filled the offices of Secretary and President of the Royal Astronomical Society.

As Radcliffe Observer Mr. Main has most conspicuously maintained for the Oxford establishment the high reputation with which it was left by his energetic and respected predecessor, Mr. Johnson. The successive volumes of observations have appeared with marked regularity, Mr. Main himself taking a much more active part in the routine computations than is usual for the director of an observatory, with the view of insuring with his comparatively small force this desirable result. Of the great value attaching to the Radcliffe observations it is unnecessary to speak here. We will only express the hope that the future conduct of the Institution may render as valuable services to practical astronomy as in the hands of Johnson and Main it has done in the past.

THE NATIONAL WATER SUPPLY

NEXT to a Conference of European powers deliberating on the fate of nations, it is difficult to imagine a Congress which may possibly more largely affect the welfare, health, and life of the people, than that to be held at the Society of Arts next week, on the subject of Water Supply.

The Congress is called at the instigation of His Royal Highness the Prince of Wales, to consider his proposition "how far the great natural resources of the kingdom might by some large and comprehensive scheme of a national character, adapted to the varying specialties and wants of districts, be turned to account not merely of a few large centres of population but for the advantage of the nation at large."

To inquire into these resources has been one of the objects of various Royal Commissions, which, though conducted with great ability, a lavish expenditure of time, and successful in collecting a large amount of very valuable information, have all failed to recommend how these bountiful stores of water can be made available. They found in the words of the Rivers' Pollution Commissioners "that an inquiry into the water supply of provincial towns must be one of great magnitude, involving a large amount of statistical and topographical investigation over the whole kingdom."

The Duke of Richmond's Commission, 1868-9, found it impossible, without further powers to carry out the inquiry, but they express their decided opinion "that the Legislature should jealously watch any proposal for a town taking water from a gathering ground at a distance from it, lest by so doing it may deprive other places nearer to such gathering ground of their natural source of supply;" and further, "that when any town or district is supplied by a line of conduit from a distance provision ought to be made for the supply of all places along such a line." This last suggestion has been adopted by the Select Committee of the House of Commons, lately ordered to "report upon the present sufficiency of the water supply of Manchester and its neighbourhood, and of any other source available for such supply," who recommend that the towns along the route of the proposed aqueduct from Thirlmere to Manchester be allowed a supply, after Manchester has been provided with twenty-five gallons per head. It is a source of regret that this Committee did not avail themselves of their full powers to inquire into all the means existing of supplying Manchester, as even should the Thirlmere scheme have proved the best, the information gained might have been useful to other districts. For though it is advisable that the inhabitants of Manchester, being accustomed to soft water, should continue to receive it, hard would probably be found equally wholesome, if pure, to those populations they propose to supply that are not at present using soft water.

Three points will probably be uppermost at the Congress—(1) Evidence to show the stores of water available; (2) How far the existing water legislation requires amendment, so as to give cheaper and quicker water powers to sanitary authorities than at present; and (3) How far it is advisable to have a National Water Supply Survey of the whole kingdom in connection with the Department of Health, technically known as the Local Government Board.

Looking to the fact that the labours of the various Royal Commissions and Select Committees have failed to recommend a scheme of provincial water supply, it is perhaps too much to hope that the present Congress will succeed; but when it is remembered that these failures prove the absolute necessity of personal examination of each district, and finding for each a scheme suited to its special requirements, we may look forward to this experience being utilised, and a scheme elaborated in which a scientific inspection of the country will play a principal part.

At this juncture it may not be without interest to glance at the present sources of supply of some of our great centres of population, and the means that are being taken to increase it.

The older palæozoic rocks forming the elevated tracts of the English Lake District, the Scottish and Welsh Hills, and Dartmoor, all of which are practically impermeable to water, lie west of a line ranging through the mouth of the Exe on the south coast, to the mouth of the Tyne on the north-east coast, and it is west of this line that the largest rainfall is received, ranging from 40 to 150 inches per annum. The rapid slopes and impermeable nature of the ground on which it falls cause it to be nearly all carried off in floods often of the most destructive character, and exceeding the dry weather flow 500 and even 1,000 times; the floods in the Silurian mountain districts amounting, according to Mr. Bateman, to a volume of 200 to 500 cubic feet of water per second derived from each 1,000 acres of area, while in dry weather the water given off by peat-mosses, and the unimportant springs found in such districts, will only amount to from one-fourth to three-fourths of a cubic foot per second.

The enormous volumes of pure water which run off the Westmoreland and Cumberland Mountains are stored to a certain extent in the numerous lakes which traverse that district, occupying true rock basins and often attaining a greater depth than the English Channel between Folkestone and Boulogne. Engineers have from time to time proposed them as sources of water supply for the crowded population of Lancashire, and even for the metropolis, and at length the House of Commons has assented to Mr.

Bateman's project of taking Thirlmere for the additional requirements of Manchester and the towns on the line of aqueduct. The rainfall is stated to be 98 inches per annum, which it is calculated will afford a supply of 64 million gallons a day, of which more than 13½ will be given back to the streams as compensation. The route to Manchester is 102 miles in length, the Lune will be crossed five miles above Lancaster, the Ribble five miles above Preston by pipes capable of conveying in the first instance, 10 million gallons a day; but the covered aqueduct from Thirlmere to the service reservoir at Bolton, will be large enough to convey 50 million gallons per day. The estimated cost of the first instalment of water will be 1¾ millions.

At present Manchester is supplied by a series of reservoirs collecting the rainfall of 18,000 acres of lower carboniferous rocks, consisting of permeable sandstones and impermeable beds of shale, which latter support the water absorbed by the pervious overlying strata. This water is not conveyed away down the dip planes of the strata, into other water-sheds, but is returned to the surface of the basin in which it falls; so that out of 45¾ inches of rainfall no less than 33 have been collected in the reservoirs. The supply from these Longdendale reservoirs will very nearly reach 25 million gallons daily, or 25 gallons per head of the existing population of Manchester and district, without any additional supply from Thirlmere.

In the Liverpool Gravitation Waterworks area, in the Rivington district, the geological conditions are similar; the drainage area is 10,000 acres, the average rainfall is 46 inches, and the mean from 1861 to 1865, was 44 inches, of which 33½ were collected, leaving 10½ inches for evaporation and absorption. Part of the Liverpool supply is derived from wells in the New Red Sandstone, the Green Lane Well having yielded no less than 3¼ million gallons per day.

The New Red series occupies an area in England of 7,431 square miles, absorbing on an average 10 inches of rain annually, or 400,000 gallons per day, for each square mile of surface, and affords over nearly the whole of the district an abundant supply of water which is described by the Rivers' Pollution Commissioners as "almost invariably clear, sparkling, and palatable, and amongst the best and most wholesome waters for domestic supply in Great Britain."

The great importance of the New Red Sandstone as a source of pure water makes its southern and eastern range under the newer formations a matter of some interest. At Scarle, near Lincoln, in a boring that attained a depth of 2,030 feet and reached carboniferous strata, it was passed through and was 786 feet thick, affording a very plentiful spring of water, which rose six feet above the surface.

Southwards the New Red series rapidly thins, but the thin end of the wedge is present at Burford, west of Oxford, where true coal measures have been reached beneath them; and still further south, at Crossness, the new boring of the Metropolitan Board of Works, after penetrating the Gault with its phosphatic basement bed, with the characteristic *Ammonites interruptus*, traversed certain red beds which are possibly referable to the Trias, and which would probably, if bored through, be found to be not less than 178 feet thick.

The Commissioners comment very favourably on the character of the waters derived from the Oolites, the volume of which is immense, the "Seven Wells," forming the head waters of the Churn, yielding two million gallons daily; the Syreford spring four millions, issuing at the base of the Inferior Oolite; other powerful springs in the Fuller's earth yield twelve and even twenty million gallons per day, which might be made available for the supply of Oxford, and other towns on the Thames, as Prof. Prestwich has ably pointed out in his "Oxford Water Supply." The Thames, above this city at Wolvercot, has an average daily summer flow of seventy-three million gallons, increasing to 742 million gallons in winter floods, which proves the quickness with which the Oolitic waters are given off, the amount absorbed by the rock being probably nearly all returned to the Thames basin, its onward progress down the dip planes of the strata towards London being stopped by lines of fault. Three million gallons of water are pumped from these oolites by the Thames and Severn Canal Company, and most of this water finds its way into the watershed of the latter river.

The Lower Greensand and Upper Greensand both yield large supplies of pure water to a large district in the south-east of England; they were proved in the deep boring at Meux's brewery, to overlie the true Devonian,[1] which rises there and form the old palæozoic ridge under the London basin. At the new boring at Crossness the lower greensand was absent, but the gault is so constantly unconformable to the lower cretaceous strata, and rests in the south-west of England on various members of the oolitic and liassic strata, that its occurrence on the red rocks of probably triassic age at Crossness is not specially remarkable, but would merely indicate more extensive denudation of the older secondary rocks there, than at Meux's brewery. This, should Mr. Godwin Austen's view of the possible continuation in that area of the Belgium and South Wales coal-field be correct, would have the effect of shortening the vertical distance to the coal-measures under the Thames basin. Be this as it may, both from the scientific and economic questions involved, it is a matter of considerable importance that the Crossness boring should be continued, and the nature of the underlying rock cleared up.

In the metropolis, Col. Bolton reports that in the month of June, 1877, the average daily quantity of water supplied by eight companies was 132½ million gallons to 3,796,000 people, living in over half a million houses, or a little less than thirty-five gallons per head during that summer month. The average daily quantity required is 125 million gallons, according to Mr. Bramwell, who proposes that London should receive an additional supply derived from wells drawing their supplies from the deep springs of the chalk, which he calculates would easily yield sixteen to thirty million gallons per day, which he would store in four reservoirs, north and south of London, at an elevation of 400 feet above ordnance datum, from which he proposes to give a separate supply for potable and fire-extinguishing purposes, at an estimated cost of 5½ millions.

Prof. Prestwich has pointed out that the first settlement of the London area was on the water-bearing gravel beds, the suburbs extending in the direction of these gravels, and that all extension stopped short at the outcrop of the London clay; but so soon as water companies introduced a supply of water derived from other areas, the northern side of London was built over. In Lancashire the middle glacial sands and gravels have taken the place of the gravels of the London area, and every exposure of sand rising through the boulder clay, marks the site of an ancient town or village, as Preston, Lancaster, Kirkham, Euxton, Leyland, Wigan, and Chorley, and numerous others.

London received its first systematic water supply in 1581 direct from the Thames, pumped by a water wheel placed in one of the arches of London Bridge by Peter Morrys, an ingenious Dutchman. This continued to afford a supply for two hundred years, and with the New River, brought by Sir Hugh Myddelton in 1613, from the chalk springs of Herts, satisfied the requirements of the metropolis up to 1723, when the Chelsea Water Works were established, followed by the Lambeth in 1785, the West Middlesex in 1806, and the Grand Junction in 1820, all taking their supplies from the Thames. Iron

[1] Determined from the fossils by Mr. Etheridge, F.R.S.

street pipes in lieu of wooden ones were introduced at the end of the last century, and the plan of filtration in 1829 by the Chelsea Company.

The tidal portion of the Thames at Hammersmith and Kew afforded a supply only thirty years ago, until the companies were at length compelled to take their supplies from above Teddington Weir, so as to be out of tidal influence. Five London Water Companies have the power to draw about 110,000,000 gallons per day from the river; its minimum flow during the minimum month of dry years is 350,000,000 gallons per diem. Mr. Beardmore estimates the amount of rainfall run off the Thames basin above Kingston from 1850 to 1868, to give a mean annual rate of 7·83 inches, while the mean rainfall at Oxford was 26·08, the rest of the rainfall being evaporated, or absorbed by vegetation. The head waters of the Thames are maintained by springs of the oolites, but these lose their volume after drought, the dry-weather flow of the river being maintained by the deep-seated springs of the chalk, which occupies an area in the Thames Basin, above Kingston, of 1,047 square miles, and has, according to Mr. Beardmore, a storing capacity of sixteen months.

Large numbers of wells have been sunk in the metropolitan area during the present century, into the Thanet Sands, underlying the London Clay; as these by pumping became exhausted, the chalk was penetrated, and the rainfall which is absorbed in the Hertfordshire and Surrey Hills, and flows down the dip planes of the strata under the London clay of the Thames Basin, was pumped up by the brewers and other large consumers. The constant tax, however, on this supply has caused a steady and increasing depression in the level to which the water will rise, and has necessitated in many instances the lowering of the pumping machinery in the metropolis.

Eighteen million gallons[1] daily of water of the River Lea that would have naturally gravitated towards London is intercepted by the New River Company, who pump their chalk wells most, when the River Lea is driest, and thus draw upon the deeper springs, which would not in ordinary course have reached the surface in that area.

Following the example of some 100 or more provincial towns that have acquired the control of their own waterworks, the Metropolitan Board of Works have laid before Parliament a bill to acquire the rights of the whole of the London water companies, which, at twenty years' purchase, are valued at fifteen million pounds, an amount steadily increasing, and have coupled it with another bill, to give effect to Messrs. Bramwell and Easton's proposal to sink chalk wells for a separate supply for drinking purposes. Influenced probably by the enormous cost of the one scheme, and the inconvenience attendant on the laying of 2,600 miles of new pipes in the other, the proposals are not supported by the ratepayers, who appear to consider "living organisms" in the water now supplied to them a minor evil. The "purchase bill" is now, however, abandoned for this session, and the "well scheme" will probably rest for the present.

An extension of Mr. Bateman's project for bringing the Vyrnwy and other head waters of the Severn to the metropolis, has recently been suggested for the future requirements of Liverpool, sixty miles distant; the watersheds between the Mersey, Dee, and Severn basins are very low, so that little tunnelling would be required. The scheme is stated by Mr. Hugh Williams, who suggested it, to be capable of yielding, if required, no less than 193,000,000 gallons of water daily, after allowing for compensation, a quantity which would suffice for the wants of six millions of our population, and could not fail to have a salutary influence on the floods of the Severn.

CHARLES E. DE RANCE

[1] The New River also receives 3½ million gallons daily from the Chadwell Spring, and the water obtained from various wells in the chalk.

NOTES

SINCE our last number appeared American science has sustained a loss which will be universally deplored. Prof. Joseph Henry, the Director of the Smithsonian Institution, whose labours for the progress of science, all the world over, have been increasing, is no more. We shall take an early opportunity of referring to his long-continued labours for the furtherance of natural knowledge among men.

WE understand that Mr. E. Roberts, of the *Nautical Almanac* office, has been requested by the India office to construct for use in India a self-acting tide-calculating machine. It will be designed not only to predict the tides at open-coast stations, but also river and shallow-water tides. It will be a great improvement on the tide-calculating machine at South Kensington (now temporarily at the Paris Exhibition), inasmuch as the tides caused by the smaller lunar perturbations will be included. Each component will be fitted with a slide, so that no error will be caused from the excentricity of the pullies. The ordinates of the curves traced by the machine being as much as eighteen inches, the use of the slides is imperative. Mr. Roberts has calculated new numbers to represent the periods of the many components, and with such success, that the actual error of any one component, after a run representing a year's predictions, will not exceed the limit of error of setting the component at the commencement. The machine will be fitted with self-regulating driving-gear, so that it can be set at the close of the day and the whole year's curves be ready for reading off by the next morning. The machine is expected to be finished towards the end of the year. Now that the immense labour (the only objection raised against the employment of tidal predictions by harmonic analysis) is superseded, it is to be hoped that the Admiralty will avail themselves of an instrument, the results of which are so vastly superior to those now obtained with considerable labour by actual computation.

PROF. HUXLEY has been elected a corresponding Fellow of the Royal Academy of Rome, in the Department of Natural History.

WE learn that the following gentlemen, all highly distinguished for their numerous original researches and published memoirs on physiological and systematic botany, have recently been elected foreign members of the Linnean Society of London:—viz., Prof. Teodoro Caruel, of Pisa, Dr. Ernest Cosson, of Paris; Dr. George Engelman, of St. Louis, Missouri, U.S.; Prof. Eduard Fenzl, of Vienna; and Prof. Julius Sachs, of Würzburg.

ON April 29 a monument, in memory of the great physicist, Alessandro Volta, was unveiled at Pavia. Most of the Italian Universities, and several foreign scientific societies had sent deputies to Pavia University for this event. The monument is a masterpiece of the sculptor Tantardini of Milan. The ceremony of unveiling was followed by a dignified celebration at the University, and upon that occasion the following gentlemen were elected honorary doctors of the scientific faculty: Professors Clerk Maxwell (Cambridge) and Sir W. Thomson (Glasgow); M. Dumas (Paris), Dr. W. E. Weber (Leipzig); Professors Bunsen (Heidelberg) and Helmholtz (Berlin), Dr. F. H. Neumann (Koenigsberg), and Dr. P. Riess (Berlin).

THE death is announced of Roberto de Visiani, "the Nestor of Italian botanists," Professor of Botany at Padua, aged seventy-eight.

WE notice the death in Berlin on April 22 of the well-known astronomer Prof. Wolfers. For many years he was connected with the Berlin Observatory, and, as editor of the *Jahrbuch* issued from this institution, he has for the past forty years rendered services of the greatest value to astronomy. His researches in meteorology have likewise made him known to a wide circle. The most important of these were his comparative statistics on the winter weather of Berlin, compiled from a long series of careful and minute observations. Prof. Wolfers was aged seventy-five at the time of his death.

M. FERDINAND HOEFFER died at Sannois, a small country-place in Seine-et-Oise, on May 8, at the age of sixty-eight years. He was the editor of the *Biographie générale*, published by Firmin Didot in sixty 8vo volumes. Most of the scientific memoirs in that immense work were written by him, and he was the author of a large number of historical works on astronomy and chemistry.

MARIETTE BEY, the Egyptologist, who has rendered such valued services to archæology, has been elected a member of the French Institute.

THE statue of the philosopher, Giordano Bruno, will be dedicated at Rome on February 17, 1879. On the same day, in the year 1600, he was burned at the stake, in Rome, by the Inquisition.

THE festive celebration of the fiftieth anniversary of the foundation of the Royal Polytechnic Institution of Dresden took place on May 1, and was attended by many eminent men of science and other persons of note.

A PROMINENT feature at the late banquet of the Berlin Geographical Society was the speech of the representative from the Paris Society. His concluding wish that the festival might serve towards the scientific fraternisation of the two nations, was greeted with loud applause, which was redoubled as the Crown Prince of Germany rose to publicly shake hands with the French Ambassador.

ONLY last week we noticed Capt. Burton's narrative of his visit in the spring of last year to the Land of Midian. The results of this visit were so full of promise for the empty exchequer of the Khediv (as Capt. Burton scolds us into spelling the title), that the almost veteran explorer returned again with a more formidable expedition in December last, and spent four months examining the region, during which the expedition travelled and voyaged upwards of 2,500 miles. They brought home some twenty-five tons of geological specimens to illustrate the general geological formation of the land; six cases of Colorado and Negro ore; five cases of ethnological and anthropological collections—such as Midianite coins, inscriptions in Nabathean and Cufic, remains of worked stones, fragments of smelted metals, glass, and pottery; upwards of 200 sketches in oil and water colours, photographs of the chief ruins, including the catacombs, and of a classical temple, apparently of Greek art; and, finally, maps and plans of the whole country, including thirty-two ruined cities, some of whose names can be restored by consulting Strabo and Ptolemy, besides sketches of many *ateliers* where perambulating bands like the gipsies of ancient and modern times seem to have carried on simple mining operations. Among the specimens are argentiferous and cupriferous ores from Northern Midian, and auriferous rocks from Southern. There are collections from three turquoise mines, the northern, near Aynuneh, already worked; the southern, near Ziba, still scratched by the Arabs; and the central, until now unknown save to the Bedouins. There are, moreover, three great sulphur beds, the northern and the southern, belonging to the secondary formation (now invaded by the trap granite), and the central, near the port of Mowilah, of pyretic origin. Rock salt accompanies the brimstone, and there are two large natural salt lakes. The whole of the secondary formation supplies fine gypsum, and in parts of it are quarries of alabaster, which served to build the ruins of Maghair, Sheéayb, Madiama (of Ptolemy), and el-Haurá (Leuke Kome), the southernmost part of western Nabathea. Specimens of the ores will be sent to Paris and London; the rest will be analysed in Cairo by a local commission, while the curiosities of all kinds, after being exhibited in Cairo, are to be sent to the Paris Exhibition.

WHAT may be called excursional education is finding very great favour with the lively French, and threatens to be applied in a variety of directions. The largest private school in Paris, that of Sainte-Barbe, near the Panthéon, which was established in the fifteenth century, and is now the property of a company, has just inaugurated a system of tours for teaching foreign languages. Forty of the pupils have been sent to Carlsruhe, in Germany, where they will be boarded in a number of families for several months, and receive their regular instruction from a staff of German teachers. Next year there will be an English tour, very likely to London. The pupils have been carefully selected from amongst those who are most likely to benefit from this practical system of international education.

SOME important improvements upon Prof. Bell's telephone have recently been made and patented by Mr. E. Cox Walker, electrician (of the firm of Messrs. T. Cooke and Sons) of York. The improvements consist in doubling or quadrupling the diaphragm and its accessories, and dividing the mouthpiece so that to each diaphragm there is a corresponding sub-mouthpiece. Instead of using two or four single magnets, Mr. Walker adopts one or two magnets somewhat of a horse-shoe shape, the coils being connected as for ordinary horse-shoe electro-magnets, and the connections made with the transmitting wire in the ordinary way. Taking the quadruplex mouthpiece as an example it might be explained thus: the ordinary single telephone mouthpiece is elongated, and instead of the orifice leading direct to the diaphragm it is divided into four smaller channels, each of which collects and directs the sound on to the diaphragms covering the magnets. Mr Walker does not have a separate diaphragm for each pole or coil, but has so constructed the under side of the mouthpiece that it nips the diaphragms tightly across the middle and around the opening containing the coils, and virtually divides them. Mr. Walker has also recently made an octoplex instrument, which, by adding to the number of coils, diaphragms, and corresponding divisions in the mouthpiece gives eight times the intensity of a single one. Besides the mouthpieces, Mr. Walker has patented improved earpieces. The instrument was exhibited at the Royal Society's *soirée* on May 1, and at the Royal Institution on May 3.

THE Montsouris Observatory has established at the Champ de Mars a pavilion where all the observations will be conducted on the same principles as at the establishment, and the principal registering apparatus in use will be put in operation before the public. The Meteorological Society has also established another pavilion where the telegraphic warnings of the international service will be posted daily. A collection of all the meteorological journals published by the several offices will be exhibited every day for comparison. From May 1 the French service publishes daily two maps giving the state of the weather at 7 A.M. in summer time. The first of these maps gives isobaric lines with the variations in the last twenty-four hours expressed in tenths of millimetres. The second gives the isothermal lines with thermometric variation in the past twenty-four hours expressed in tenths of centigrade degrees. The isobaric map shows, by conventional signs, the state of the sky, force and direction of winds, and state of the sea. The isothermal map shows, by other signs, the extent of rains, their importance, and the limits of congelations. The Pic du Midi and Puy de Dome observatories will also send the results of their daily observations, which will be posted in a conspicuous part of the establishment.

LIEUT. G. R. R. SAVAGE, R.E., writing from Roorkee, North-West Provinces, India, sends us an account of some interesting experiments he has been making on long-distance telephones. He constructed telephones expressly for long-distance work, and succeeded in getting a bugle-call heard distinctly over 400 miles of Government telegraph line, the wire being one of the four or five main up-country telegraph wires which are carried on one set of posts. The telephones used, Lieut. Savage constructed with about 400 ohms of No. 38 gauge wire, vibrating disc about 2½ inches diameter, the sending vibrating disc thicker a *little* than the receiving one. It seems to him right to oppose the work done at the receiving end as little as possible by having a very thin vibrating disc; while he had noticed that, *cæteris paribus*, a thicker disc approached to a telephone magnet gives a greater deflection on a distant very sensitive galvanometer, so long, of course, as it is not too thick. Lieut. Savage asks the reason for the following circumstance:—Taking off the vibrating disc of a telephone, and tapping the magnet with any diamagnetic substance, brass, glass, &c., the tapping sound is heard distinctly at a distant telephone. This cannot be caused in the same way as the current in Prof. Bell's telephone; it must be caused, he supposes, by the particles of magnet being caused to vibrate longitudinally, and as the coil does not vibrate in unison with the particles of the magnet, the permanent lines of magnetic force must be cut by the coil, and hence a current. Hence, he asks, if this is the case, might not there be two causes combined producing the effect in Prof. Bell's telephone, both approach of disc and also longitudinal vibrations? Lieut. Savage constructed a small induction coil with soft iron core, the outer and inner coil the same. He heard and sent messages easily seventy or eighty miles by joining the two coils separately in circuit with the sending and receiving telephone. Of course there was no *increase* in any way, as no energy was expended on the current by the simple induction coil; there was a slight decrease in the sound. He thinks about 350 ohms of No. 38 wire makes the best coil for a telephone magnet ½-inch diameter.

MR. C. F. CREHORE, of Boston, U.S., sends us an amusing incident, *à propos* of the subject of fetichism in animals referred to by Mr. Romanes recently in NATURE. A brave, active, intelligent terrier, belonging to a lady friend, one day discovered a monkey belonging to an itinerant organ-grinder, seated upon a bank within the grounds, and at once made a dash for him. The monkey, who was attired in jacket and hat, awaited the onset with such undisturbed tranquillity that the dog halted within a few feet of him to reconnoitre. Both animals took a long steady stare at each other, but the dog evidently was recovering from his surprise, and about to make a spring for the intruder. At this critical juncture, the monkey, who had remained perfectly quiet hitherto, raised his paw and gracefully saluted by lifting his hat. The effect was magical; the dog's head and tail dropped, and he sneaked off and entered the house, refusing to leave it till he was satisfied that his polite but mysterious guest had departed. His whole demeanour showed plainly that he felt the monkey was something "uncanny," and not to be meddled with.

THE earthquake of April 26 in the vicinity of Constantinople was felt even more severely farther inland. At Nicomedia damage to the value of £300,000 was caused, and an entire village was destroyed with a loss of forty lives. Three smart shocks of earthquake were felt at 7 A.M. on the 14th inst., at Hennebout (Morbihan, France), the motion being from west to east.

THE Society of Telegraph Engineers have appointed a special meeting on Thursday, the 23rd inst., at the Institution of Civil Engineers, 25, Great George Street, Westminster, when a paper will be read by Mr. W. H. Preece, on the connection between Sound and Electricity, illustrated by Prof. Hughes' recent discoveries.

JANSEN, MCCLURG AND CO., of Chicago, will shortly publish a new and greatly enlarged and improved edition of Prof. Jordan's "Manual of the Vertebrates of the United States." The section on fishes, the *Nation* states, will be entirely rewritten.

A TELEGRAM from Adelaide, dated the 8th instant, intimates that copious rains have fallen in South Australia. As heavy rains have been previously reported from other parts of Australasia and Cape Colony, the great drought which has been so disastrous over the greater part of the Southern hemisphere may now be regarded as at an end.

THE Rev. James M. Crombie, F.L.S., author of "Lichenes Britannica," has been appointed to the Lectureship on Botany at St. Mary's Hospital, recently held by Dr. H. Trimen.

AMONG the scientific productions of Germany during the past month, we notice a new edition of Liebig's classic "Chemische Briefe," "Beiträge zur fossilen Flora Schwedens," by A. G. Nathorst (Stuttgart); "Astronomisch-geodätische Arbeiten in 1876," by the Prussian Geodetic Institute (Berlin); "Die Familien-diagramme der Rhocadinen," by F. Schmitz (Halle); "Geologie der Insel Luzon," by R. von Drasche (Vienna); "Systematisches Verzeichniss der Macro-lepidopteren von Nordamerika," by B. Gerhard (Berlin); "Das Klima Ostasiens" by H. Fritsche (Leipzig); "Die Käfer von Nassau und Frankfurt," by L. von Heyden (Wiesbaden); "Die Figur der Erde," by H. Bruns (Berlin); "Bericht über die 1 u. 2 Jahresversammlung der deutschen ornithologischen Gesellschaft," by F. Cabanis (Leipzig); the fifth edition of Prof. Lenz's "Die Reptilien, Amphibien, Fische und Wirbellosen Thiere;" "Der Mensch und das Thierreich," by Professors Krass and Landois, of Münster; "Was da kriecht und fliegt!" by Prof. Taschenberg; and "Europas Kriechthiere und Lurche," by Dr. Knauer, of Vienna.

SEVERAL correspondents write concerning a bright meteor seen on Sunday night. Mr. Whitley Williams saw it when in the open fields, about three-quarters of a mile west of Lillie Bridge. The meteor bore 1° or 2° to the west of north, and elevated approximately 20° above the horizon. It was very brilliant, even dazzling in appearance, its light having a bluish shade like that of burning magnesium. It descended from right to left at an apparent angle of 60° or more with the horizon, and described an arc of 5° or 10°, at the latter end of which it was hidden behind a cloud. The sky was overcast with a few very black clouds, and only one or two stars visible. The meteor gave the impression of being very near. A correspondent at Higher Walton, near Preston, May 14, saw it about 8.51 P.M. in a direction almost due north. It was travelling from east to west; altitude when first seen, about 60°, when last seen, about 15°. Its velocity was comparatively slow, being visible for five or six seconds. During the motion a tail, the length of which subtended an angle of about 3°, followed the nucleus. When near the end of its motion the tail disappeared, and the nucleus broke up into several pieces, and shortly disappeared. No sound was heard. "D. R. S." saw it from Kirknewton, Edinburghshire. The meteor seemed to rise from a point about 30° east of the moon at the time, and travelled in rather a leisurely manner through an arc of about 73°, in a direction of about north-west by north, leaving a trail of stars behind it, then burst into pieces and disappeared, without any report. It was of a fine violet colour. It seemed oblong in form and irregular in outline from giving off sparks so rapidly.

THE additions to the Zoological Society's Gardens during the past week include a Jaguar (*Felis onça*) from South America, presented by Major Wood; a Two-spotted Paradoxures (*Nandinia binotata*) from West Africa, presented by Capt. E. J. Hawes; a Black-backed Jackal (*Canis mesomelas*) from South Africa, presented by Mr. Richard Seyd, F.Z.S.; a Toque Monkey (*Macacus pileatus*) from Ceylon, presented by Master R. C. Heyworth; a Bonelli's Eagle (*Nisaetus fasciatus*), European, presented by Lord Lilford, F.Z.S.; a Leadbeater's Cockatoo (*Cacatua leadbeateri*) from Australia, presented by Mrs. Tennent; a Goffin's Cockatoo (*Cacatua goffini*) from Queensland, presented by Mrs. Pitt; a White-backed Piping Crow (*Gymnorhina leuconota*) from Australia, presented by Mr. John Ritchie; three Water Ouzels (*Cinclus aquaticus*), European, presented by Mr. R. J. L. Price, F.Z.S.; a Slow Loris (*Nycticebus tardigradus*) from Malacca, received in exchange; a Darwin's Pucras Pheasant (*Pucrasia darwini*), a Wonga-wonga Pigeon (*Leucosarcia picata*), nine Chilian Pintails (*Dafila spinicauda*), bred, a Reindeer (*Ranifer arandus*), born, in the Gardens.

ACADEMIC LIBERTY IN GERMAN UNIVERSITIES[1]

THIS liberty without control is a subject of astonishment to most strangers who know it only by certain very apparent eccentricities. They cannot understand how we are able, without great inconveniences, to leave young people to themselves in this way. The German remembers the student-period as the golden age of his life; our literature and our poetry are filled with the expression of this sentiment. We do not encounter anything similar to it among other European peoples. The German student is the only one who tastes an unmingled joy at the time when, in the first delight of his young independence, yet free from the anxieties of mercenary work, he may consecrate his hours exclusively to all that is noblest and best in science and in the conceptions of humanity. United by a friendly rivalry with numerous comrades devoted to the same efforts, he finds himself daily in intellectual communication with masters from whom he learns what is the movement of thought among independent spirits. I appreciate at its full value this last advantage, when, looking back, I recall my student days and the impression made upon us by a man like Johannes Müller, the physiologist. When one finds himself in contact with a man of the first order, the entire scale of his intellectual conceptions is modified for life; contact with such a man is perhaps the most interesting thing which life may have to offer.

You possess, my young friends, in this liberty of German students, a precious and glorious legacy of past generations. Preserve it in order that you may leave it in your turn to those who will come after you, and strive to ennoble and purify it still more. To guard it intact you have, each for himself, to see that the studious youth of Germany continue worthy of the confidence which has secured for them so high a degree of liberty. There is here for feeble characters a gift as calamitous as it is precious for the strong. Do not be astonished that statesmen and fathers of families think sometimes of instituting among us a system of surveillance and control analogous to that which exists in England. There is no doubt that such a system would save many whom liberty allows to run to ruin. But the State and the nation have more to expect from those who are capable of supporting liberty and whose efforts and work are the results of their own individual energy, of their dominion over themselves, and their love of science.

I have spoken above of the influence which may be exercised by intellectual contact with remarkable men; this leads me to point out another characteristic feature which distinguishes German universities from those of England and France. With us the student goes, as soon as possible, to seek instruction from masters who have proved their merit by doing something for the progress of science, which, in our eyes, is the best mark of their fitness to educate. Yet this is a thing which excites great astonishment among the English and French. They attach more importance than the Germans to a pretended talent for instruction, which consists in the faculty of expounding the subject of instruction in a clear and well-ordered form, and, if possible, in an eloquent and interesting manner, calculated to captivate the attention. At the Collége de France, the Jardin des Plantes, as also at Oxford and Cambridge, the lectures of renowned speakers are the rendezvous of the fashionable and cultivated world. In Germany we are not only indifferent to the oratorical apparatus, we are hostile to it; we undoubtedly neglect too much the external form. There is no doubt that a good exposition demands from the listener much less sustained efforts than a bad one; it enables the subject to be comprehended much more surely and much more completely, and with a well-ordered arrangement, bringing into strong relief the principal points and the divisions, much more can be overtaken in the same space of time. I do not pretend, then, to justify the contempt of form, which we often push too far, both in speaking and in writing. But it cannot be denied that many men of great intellectual originality and of remarkable scientific value, have a dull, painful, and embarrassed elocution. Yet I have often seen such professors attract numerous and faithful hearers, while orators void of thought astonished at their first lecture, fatigued at the second, and were deserted at the third. He who wishes to inspire his audience with a complete conviction of the truth of what he advances, ought, above all, to know from personal experience what produces conviction. It is necessary then that he has known how to advance alone into a region where no one has ever broken ground; in other words he must have worked upon the frontiers of human science and conquered for himself new domains. A master who presents only results acquired by others suffices for scholars to whom authority is given as the source of their science, but not for those who desire to deepen their convictions to their final foundations.

There is here, you see, gentlemen, a new sign of confidence given you by the nation. There are neither fixed courses nor fixed professions imposed upon you. You are treated as men whose free adhesion must be gained, who know how to distinguish between being and seeming, whom it is no longer sought to persuade by appealing to any authority whatever, and who, moreover, would not allow themselves to be persuaded in that fashion. It is sought, more and more, to provide you with the means of drinking science at the very fountain, either in books and historical collections, or by observation of objects and natural pheomena and by experiments. The smallest German universities have their own libraries, their mineralogical collections, &c. As regards the organisation of laboratories of chemistry, micrography, physiology, physics, Germany is ahead of all other European countries, who are only just beginning to seek to rival us. In our own university, we shall assist in a few weeks at the opening of two important establishments devoted to education in the natural sciences.

To obtain the free conviction of the pupils, it is necessary that the conviction of the masters be freely expressed; *liberty of education* is demanded. That has not always been protected from all encroachment in Germany more than in neighbouring countries. In times of political and religious strife the dominant parties have often interfered in the domain of science; but the German nation has always regarded such interferences as encroachments upon sacred ground. Here, again, the progress of political liberty in the new German Empire has been salutary. To-day, in the German universities, the most extreme results of materialistic metaphysics, the most daring speculations in the direction of the Darwinian theory of evolution, may be published without hindrance, as well as the most complete deification of the infallible Pope. No more than on the floor of European parliaments is it permitted to calumniate the intentions and outrage the person of an opponent—these are proceedings which have nothing to do with the discussion of a scientific proposition. It is also forbidden to excite to the commission of acts interdicted by the laws; but we may, without the least hindrance, discuss *scientifically* any controverted *scientific* point whatever. Liberty of education, in this sense, does not exist in the English and French universities. At the Collége de France, even a man of so high a scientific reputation as Ernest Renan has been placed under interdict. The tutors of the English universities may not diverge by a hair's breadth from the dogmatic system of the Anglican Church without exposing themselves to the censure of the archbishops and losing their pupils.

It remains for me to consider our liberty of education in another aspect. I wish to speak of the liberality with which our universities award the authority of professor.

In the etymological sense of the term, a *doctor* is a man *who teaches*, or at least, a man recognised as capable of teaching. In the universities of the middle ages, every *doctor* who found

[1] Rectorial Address of Prof. Helmholtz, F.R.S., at the University of Berlin. Continued from p. 53.

pupils, might be constituted *master*. In the course of time the practical signification of this title has been altered. Most of those who obtain it do not propose to teach; this title is only useful to them as a public mark of their scientific instruction. It is only in Germany that there still subsist some vestiges of the rights formerly attached to the doctorate. It is true that in consequence of the change which has taken place in the signification of the title, and in consequence of the increasing specialisation of the various branches of education, we require of doctors, who wish to instruct, a most searching proof of their profound knowledge of the subjects which they desire to be authorised to profess. For the rest, in most of the German universities, the legal rights of these doctors authorised to instruct, are exactly the same as those of ordinary professors; in some there are certain restrictions which are of little practical importance. The oldest masters, especially the ordinary professors, have no other real advantage than that of having more completely at their disposal the material means of study furnished by the State, and necessary for instruction in certain departments of science; besides, they are legally intrusted with the conduct of the university examinations, and, in fact, the State examinations are oftenest intrusted to them, which naturally exercises a certain influence on the most timorous students. But the influence of examinations is much exaggerated. In consequence of the come-and-go movement of the students, candidates are often tested by examiners whose courses they have never attended.

Of all our university institutions, that of *privat-docent* is what most confounds strangers. They are astonished, not without envying us, at finding among us so many young men disposed to devote themselves to hard scientific work, for the most insignificant fees, without fixed salary and without any assured prospect for the future. And, always from the practical and material point of view, they wonder that the faculties admit so easily, and with such complaisance, these young people who may, at any moment, be transformed from assistants into competitors, and that in a situation so delicate, the employment of annoying methods of competition is so rare and exceptional a thing.

The right of filling vacant chairs, as well as that of giving authorisation to the *privat docenten* belong to the faculty, *i.e.*, to the assembly of the ordinary professors, although the former of these rights is not absolute, and the final appeal is not to the faculty. These assemblies are in the midst of the German universities a relic of the ancient colleges of doctors who inherited the privileges of the primitive corporations. They also represent the union of the graduates of old, but much reduced, and organised with the concurrence of the governments. The custom is that for the nomination of the ordinary professors the faculty presents three candidates for the choice of the Government. The latter, it is true, is not rigorously obliged to abide by the candidates presented, but it is extremely rare that the presentations of the faculty have not been respected except at epochs when party strifes were very hot. Unless for very potent considerations, it is always an extremely weighty responsibility for the representatives of the executive power to institute against the wish of a competent body, a professor who will have to give publicly the proofs of his merit before a numerous auditory.

The members of the faculty have the strongest motives for strengthening as much as possible the teaching body. To be able to give one's self with joy to the labours of the professoriate, the most essential condition is that of being assured that you will not have to speak before too small a number of intelligent auditors. Moreover, the income of many of the professors depends to a large extent on the number of students. Each professor ought, then, to desire that the faculty to which he belongs draws as many and as intelligent students as possible. This end can only be attained if all the masters—professors and *privat docenten*—are chosen from among the most distinguished men. On the other hand, the efforts made by a professor to accustom his students to work energetically and with intelligence, can only be successful if he is seconded by the other members of the faculty. Finally, the concourse of distinguished colleagues contributes to maintain, in university circles, a more interesting, more instructive, and more active life. To make these reasons yield to other considerations a faculty must already have fallen very low, have lost not only the feeling of its dignity, but also that of the commonest worldly prudence; such a faculty would soon come to ruin.

As to the phantom of a rivalry among the professors, with which it is sought sometimes to frighten public opinion, nothing of the kind can be produced when the teachers and the students are what they ought to be. In the first place, it is only in large universities that there exist two chairs for the same branch of science; and in this case, if there is no difference between the official definition of the two chairs, there is certainly one between the scientific tendencies of the two professors, and these may divide the work in such a way that each reserves the subjects in which he is most competent. Two distinguished professors, who are thus complementary to each other, are so powerful a centre of attraction to students that neither of the two need fear to see the number of his auditory diminish, when even a certain number of the less zealous may divide and follow only one of the two courses.

The injurious effects of rivalry are especially to be feared when one of the professors does not feel himself established in his scientific position. Even this may not exercise any influence upon the decisions of the faculty so long as the case concerns only one or a small number of the voters.

The exclusive domination of one scientific school may be more unfortunate for a faculty than the personal interests of which I have spoken. It may in fact be foreseen that when the school will have had its day, the students will gradually resort to other universities. Years may thus pass, and the faculty be paralysed for a long time.

It is easy to see, under the sway of this system, how many efforts the universities have made to attract to them all the scientific leaders of Germany; for this it is enough to inquire how many men of original genius are found outside the universities. We may have some idea of the result of such an inquiry, for we are rallied on the fact that all German science is a science of professors. If we consider England, we find immediately men like Humphrey Davy, Faraday, Darwin, Grote, who have no connection with the English universities. In Germany, on the contrary, except the *savants* whom the Government have excluded for religious or political motives, like David Strauss, and except those who, in the quality of members of German academies, have the right of giving lessons in the universities, like Alexander and Wilhelm von Humboldt, Leopold von Buch, &c., the number of those who are found outside the universities is very small relatively to the number of those who have been professors in them. If we make the same calculation for England, we arrive at an inverse proportion. I have always considered it a very striking thing that the Royal Institution of London, a private society wishing to have for its members and for a distinguished public short courses of lectures on the progress of the natural sciences, has been able permanently to attach to itself for this purpose men having so great a scientific authority as Faraday and Humphrey Davy. There is not here a question of salary; evidently these men were attracted by an auditory composed of men and women of independent spirit. In Germany the universities are incontestably the places of education which always exercise the most powerful attraction for those who wish to instruct. It is clear that this power of attraction arises from the fact that we cannot hope to find elsewhere an audience, not only well prepared, used to work, and capable of enthusiasm, but also disposed to form personal convictions; without a disposition of this kind the science of the master will not bear fruit in the pupil.

Thus is manifest in all the organisation of our universities that respect for the liberty of personal convictions, a respect more profoundly rooted among the Germans than among their Aryan brothers of the Celtic or of the Latin branch. Among these political and practical motives have greater sway. They are always disposed, and this, it appears, in all sincerity, to withdraw from the spirit of research the examination of things which appear to them indisputable as being the foundations of their political, social, and religious organisation; they consider it perfectly legitimate to tell the young people not to cast their eyes beyond the limits which they themselves have agreed not to pass.

When we hold as indisputable a certain order of questions, even when the domain of these questions is out of the way and narrow, even when we have excellent intentions, it becomes necessary to maintain in a determined path those who study, and the master must avoid everything which would disturb authority. Then independent convictions can only be spoken of in a very restricted sense.

You have seen that our predecessors have judged otherwise. If sometimes they have energetically combatted certain results of scientific research, at least they have never attacked the root of the tree. An idea which did not rest on a personal conviction appeared to them to have at bottom no value. In their inmost heart they always guarded the firm persuasion that liberty alone is able to remedy the abuses of liberty, and that a more mature science would rectify the errors of an incomplete science. The sentiment which urged them to shake off the yoke of the Roman Church is also that under the sway of which the German universities have been organised.

But every institution founded on liberty is obliged to count on the intelligence and judgment of those who use the liberty. Independently of what has been said above on the subject of the decisions which the students have to take for themselves in what concerns the direction of their studies and the choice of their masters, the reflections which precede show also the influence which they may exercise on the masters themselves. It is a difficult thing to have to continue the course commenced by a colleague, and that difficulty is presented at the outset of every semester. At every moment the progress of the course obliges us to fall back upon what has been previously said, to consider the same questions from other points of view and in another order. The master would soon tire of this ungrateful task, if he did not find support in the zeal of his audience. In order to be at the height of his mission, he must feel himself sustained and understood by a sufficient number of intelligent pupils. The flocking of an audience to the lessons of a master has no little influence on his nomination or his advancement; and it has an influence also upon the whole of the teaching body. All this system rests upon the idea that the general current of the opinion of the students cannot long be at fault. The majority among them come to us with a reason sufficiently formed by logic, with a sufficient habit of intellectual effort, with a judgment so considerably developed by a knowledge of the best models, to be able to discern the truth from a phraseology which has only the appearance of truth. Among students we may already distinguish the *élite* who will be the intellectual guides of the new generation, and who, in a few years, may perhaps attract the attention of the world. They are those who, especially, in scientific matters, determine the opinion of their comrades; the others involuntarily allow themselves to be guided by them. Naturally, young spirits, inexperienced and impressionable, are liable to fall momentarily into error; but, in short, we may be sure that they will always return soon to just ideas.

Such are, at least, those whom the lyceums have sent to us hitherto. It would be dangerous for the universities to see arriving in great numbers, students less cultivated. It is necessary that the general spirit of the students should not decline. If that happened, the dangers of academic liberty would surpass its advantages. We ought not then to accuse the universities of pride or pedantry, when they admit only with circumspection students educated outside the lyceums. It would be more dangerous still for a foreign pressure to introduce into the faculties masters who would not be fully qualified for having the scientific independence of an academic professor.

Do not forget, then, dear comrades, that you have a great responsibility. This glorious legacy of the past, of which I have already spoken, you have to preserve, not only for our own nation, but also to serve for example to a great portion of humanity. You are bound also to prove that youth is capable of enthusiasm for the independence of convictions and of working for it. I say working. In fact, the independence of convictions does not consist in lightly accepting hypotheses without proofs; it can only be the fruit of experiments and of persevering labours. It is your duty to show that the convictions, founded on personal researches, are germs most fruitful of new ideas, and furnish better rules of conduct than the direction of the best-intentioned authority. Germany, who, in the sixteenth century was the first to strive for the liberty of convictions, who suffered and was martyred for them, is yet in the van of the fight. A noble mission is allotted to her in the history of the world, and you are called to contribute to its triumph.

REMARKABLE CHANGES IN THE EARTH'S MAGNETISM[1]

ONE of the most important, scientifically, of the special lectures at the Geographical Society, was that by Capt. Evans, in March last, on the subject of terrestrial magnetism. The concluding portion, especially, is of high scientific importance. Capt. Evans gave a historical sketch of the subject of terrestrial magnetism from the time of the discovery of the dip of the magnetic needle. After speaking further on various departments of his subject, Capt. Evans went on to say:—

"We have now passed in review the successive stages of development of our branch of knowledge, from the pregnant epoch when its principles were enunciated by Gilbert, till the period when the well-directed munificence of his own and other Governments dotted the earth's surface with observatories, and despatched land and sea expeditions, specially equipped, for the determination of the magnetic elements. We have seen how a few earnest and gifted men have, by long and patient analysis, laid the foundations for future generations to build upon as regards theory, and unravelled the apparently inextricable web surrounding the needle's daily and yearly movements; tracing these movements to their primary source, the sun: and how by the perseverance of states and of individuals, we are now in possession of accurate knowledge as to the distribution of magnetism over the surface of our globe, as represented by the variation and dip of the needle, and by the measure of the force connected with those component elements. But the task, from a scientific point of view, is far from completed while we remain in ignorance of the causes of greater changes in the earth's magnetism going on from year to year, and so on, possibly through æons of time. From a practical point of view, so far as the interests of men are concerned, the collection of records will be a never-ending task, for every generation must observe and chart the magnetic elements of its time.

"The subject of secular change is thus one of such great interest that the remaining portion of my lecture must be chiefly devoted to it. The active mind of Halley was drawn, as one of the first, to the probable nature of the causes: collecting such observations of the variation of the compass as had then been made, and projecting them on polar maps, he found that the convergence of the several directions of the needle led to two points in each hemisphere. On this he enunciated the proposition 'that the whole globe of the earth is one great magnet, having four magnetical poles or points of attraction; near each pole of the equator two; and that in those parts of the world which lie near adjacent to any of these magnetic poles the needle is governed thereby, the nearest pole always being predominant over the more remote.' Halley saw, as he confessed with despair, the difficulties attending the proposition, 'as never having heard of a magnet having four poles,' but there were the facts manifested by the earth, and he was too sagacious and sound a philosopher to pass them by. He accordingly propounded a theory which, however fantastic it may now appear, and perhaps did at the time he wrote, has nevertheless within it the fire of genius, and may probably be found yet to contain some sparks of truth. To account for the four poles, and at the same time for the secular change of the variation, he conceived that the earth itself might be a shell, containing within a solid globe, or terella, which rotated independently of the external shell: each globe having its own magnetic axis passing through the common centre; but the two axes inclined to each other and to that of the earth's diurnal rotation. It is not difficult to follow the movements of the consequent four imaginary poles in solution of the problem.

"Hansteen working at the same problem a century after Halley [1811-19], and much on the same lines, came nearly to the same conclusion with regard to the four poles of attraction: and he rendered justice to Halley by recognising him as the first who had discovered the true magnetic attraction of the globe. Hansteen, with the material at his command, went however a step further, and computed both the geographical positions and the probable period of the revolution of this dual system of poles or points of attraction round the terrestrial pole. From these computations he found that the North American point or pole required 1,740 years to complete its grand circle round the terrestrial pole, the Siberian 860 years; the pole in the Antarctic regions south of Australia, 4,609 years; and a secondary pole near Cape Horn, 1,304 years.[1] The influence of these laborious investigations on the minds of subsequent inquirers may easily be imagined.

"The matured views of Sir Edward Sabine on the secular changes—enunciated in the clearest manner in 1864-72—are deserving of the highest consideration. An ardent admirer of

[1] From Lecture at the Royal Geographical Society, March 11, by Captain F. J. Evans, C.B. F.R.S, Hydrographer to the Admiralty.

[1] *Untersuchungen über den Magnetismus der Erde.* Christiania, 1819.

the genius and no less of the sagacity of Halley, he in part follows Halley's views, and considers that two magnetic systems are directly recognisable in the phenomena of the magnetism of the globe; the one having a terrestrial, the other a cosmical origin. The magnetism *proper* of the globe, with its point of greatest attraction (*i.e.* in the northern hemisphere) in the north of the American continent is the stronger; the weaker system, or that which results from the magnetism induced in the earth by *cosmical action*, with its point of greatest attraction is, at present, in the north of the Asiatic continent. Sir Edward Sabine also expresses his belief that 'it is the latter of these two systems which by its progressive translation, gives rise to the phenomena of secular change, and to those magnetical cycles which owe their origin to the operation of the secular change.'[1]

"Reviewing these several hypotheses by the light of observations made in recent years, it is difficult, and indeed in some directions, impossible to recognise their accordance with changes now going on: there can be no doubt, notwithstanding, that Halley and Hansteen analysed their facts with skill, and that their deductions were borne out by those facts. In explanation of this anomaly it is necessary to glance retrospectively on the changes in progress at the times in which these philosophers gave utterance to their views [1700–1819]. During this long interval, and, so far as relates to parts of the northern hemisphere, for a century before, there was in the higher latitudes a general movement of the north end of the needle in the following directions:—

"Over all that area (embracing the Atlantic and Indian Oceans) from Hudson's Bay to about the meridian of the North Cape o Europe, and from Cape Horn to about the western part of Australia, the north end of the needle was successively drawn to the west at a maximum rate of 8′ or 10′ a year. From the meridian of the North Cape of Europe to that of 130° east, it was successively drawn to the east, while from thence to Hudson's Bay it was nearly stationary, or perhaps oscillated a little: in the southern hemisphere, from about the western part of Australia to Cape Horn, the movement was throughout to the east at the maximum rate of 7′ a year. There was thus a general uniformity of movement: in that hemisphere [dividing the globe into *eastern* and *western* hemispheres] which includes the Atlantic and Indian Oceans, the needle was constantly drawn more and more to the west; in the hemisphere embracing the Pacific Ocean, more and more to the east.

"So far then to the early part of the present century we can trace a harmonious movement of the needle over the whole globe, justifying the conclusions of our old philosophers; but in the year 1818 at London, and generally contemporaneous with that epoch throughout Europe and North Africa, the westerly progress of the north end of the needle ceased, and an easterly movement commenced; this continues to the present time, and with a yearly increasing rate. But in the South Atlantic during this period the westerly movement has never ceased; it is still going on, and in some parts with rapidity. Here, then, is a marked dislocation of the harmonious regularity embodied in Halley's and Hansteen's calculations and conceptions.

"The matured views of Sir Edward Sabine, to which I have drawn attention, seem to anticipate the difficulties attendant on this new and complex movement; for, if I apprehend his meaning correctly, they imply that the poles of attraction which have a terrestrial source, *i.e.* the *magnetic poles*, are not subject to translation.[2]

"The hypothesis, if further followed, is nevertheless beset with difficulties; for we can scarcely conceive changes due to *cosmical* action to be otherwise than general in character, and to affect the whole globe. Thus, if the progressive translation of the induced or weaker system in Northern Asia—and presumably of that in the southern hemisphere—were the direct causes of the secular charges, we should anticipate uniformity in the general movements of the needle as manifested by its variation and dip over the earth's surface. But this is contrary to modern experience; for in some regions great activity of movement, both in the direction of pointing and in the inclination of the needle, is going on; in others there is comparative repose in both elements; while in another region the needle remains nearly constant in its direction, while its inclination sensibly varies from year to year. For example:—

[1] *Phil. Trans.*, 1864, Art. vi.; 1863, Art. xii.; 1872, Art. xv.

[2] So far as modern observations bear on the position of the magnetic poles, they indicate permanency rather than change of place.

"A region of remarkable activity presents itself in the South Atlantic Ocean: a great part of the seaboard of South America extending to Cape Horn, and including St. Paul's Rocks, Ascension, St. Helena, and the Falkland Islands, with their adjacent seas, are embraced therein. In some parts of this area the westerly movement of the needle exceeds 7′ or 8′ a year, and has so progressed for nearly three centuries. On the American coast the dip of the south end of the needle *decreases* from 7·5′ to 4′ yearly, while from the Cape of Good Hope to Ascension it *increases* from 5′ to 10′ yearly. We have here, within narrow limits, a noteworthy dislocation of the observed phenomena.

"Another region of activity, so far as is denoted by the changes of variation, extends over Europe, Western Asia, and North Africa. Here the needle, in opposition to the protracted westerly movement going on in the South Atlantic, commenced moving to the eastward in the early part of this century; it has a progressive rate which in some parts now amounts to 10′ a year. The dip diminishes in this region seldom more than 3′ a year.

"A region of activity, so far as the dip is concerned, but with little change in the variation, is to be found on the west coast of South America; at Valparaiso, as at the Falkland Islands, the south dip decreases at the rate of 7′ yearly, but in sailing northward and reaching the 10th degree of south latitude, this active movement appears to cease.

"But little activity in either element now exists over the habitable part of the North American continent or in the West Indies. Throughout China there is little change in the variation, but an *increasing* dip of 3′ or 4′, and thus a reverse movement to that going on in Europe.

"Over a great part of the Western Pacific Ocean, as also in Australia and New Zealand, there is so little change in the two elements that this may be termed a region of comparative repose.

"These are a few facts relating to secular changes going on in two magnetic elements within our own time; and what are the inferences to be drawn therefrom? They appear to me to lead to the conclusion that movements, certainly beyond our present conception, are going on in the interior of the earth; and that so far as the evidence presents itself, secular changes are due to these movements and not to external causes: we are thus led back to Halley's conception of an internal nucleus or inner globe, itself a magnet, rotating within the outer magnetised shell of the earth.

"We need not here pause to discuss the probability of this fanciful conception of the old philosopher, but proceed to examine how far the behaviour of another element, the intensity of the earth's magnetism, confirms the view that movements are going on in the interior of our globe. In common I believe with all those who have pursued the study of this element from the time when Sabine's original memoir to the British Association [1837] threw so much light on this special division of the subject, I had conceived that stability, within very limited conditions, was a distinctive condition of the earth's force; and that it was alone by watchful attention to the instruments of precision devised for its determination that changes in short intervals of time, such as a generation, could be detected.[1] If we turn to the results obtained in this country through nearly half a century, it is possible that an *increase* of two or three hundredths of the total force may be found. In Italy at the present time the annual *decrease* has been given by that active observer, the Rev. Father Perry, as ·004; so also on the North American continent, where, as we are told by the zealous magnetician, Schott, there is evidence of the force slightly increasing at Washington, of being stationary at Toronto, in Canada, and slightly decreasing at Key West, in the Gulf of Mexico. So far stability, within very small limits, obtains over a very large part of the northern hemisphere. If, however, we turn to the continent of South America and its adjacent seas (parts of which are regions of marked activity as denoted by changes in the variation and dip of the needle), we shall find a diminution of the intensity of the earth's force now going on in a remarkable degree; an examination of the recent observations made by the

[1] The investigations of that able magnetician, Mr. Broun, lead him to consider that the earth's magnetic force increases and diminishes from day to day by nearly the same amount over the whole globe. These increases and diminutions have been traced to the action of the sun in such a way that the greatest of them recur frequently at intervals of twenty-six days, or multiples of twenty-six days—a period attributable to the sun's rotation.

Challenger's officers[1] at Valparaiso and Monte Video, compared with those made by preceding observers, show that within half a century the whole force had respectively diminished one-sixth and one-seventh—at the Falkland Islands one-ninth. Farther north we find at Bahia and Ascension Island, in the same period of time, an equally marked diminution of one-ninth of the force. This area of *diminishing* force has wide limits; it would appear to reach the equator and to aproach Tahiti on the west and St. Helena on the east; at the Cape of Good Hope there is evidence of the force *increasing*.

"Such are the facts, and how are we to interpret them? Whichever way we look at the subject of the earth's magnetism and its secular changes, we find marvellous complexity and mystery; lapse of time and increase of knowledge appear to have thrown us farther and farther back in the solution. The terella of Halley, the revolving poles of Hansteen, and the more recent hypotheses of the ablest men of the day, all fail to solve the mystery. We must not, however, be discouraged at these repulses in the great conflict for the advancement of human knowledge. The present century has been productive of keen explorers in the field of terrestrial magnetism; others emulous of fame are pressing rapidly from the rear, and knowing as we do that knowledge shall be increased, we may confidently anticipate the day when this, one of Nature's most formidable secrets, shall be revealed."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

At the annual meeting of the Convocation of the University of London on May 14, a report from the annual committee was presented which recommended closer union and co-operation of the colleges and medical schools affiliated to the University with each other and with the Senate, and also more direct participation by the University in the work of higher education and in the encouragement of mature original work. The following resolutions were carried by large majorities after an animated debate, in which Drs. Odling, Payne, Baxter, Pye-Smith, and Weymouth, and Messrs. Hutton, Carey Foster, R. N. Fowler, and Fitch, took part:—1. That while Convocation recognises the advantages of examinations conducted by a body independent of the teachers of the candidates for degrees, it is expedient that the course of study pursued in those institutions should be brought into closer connection with the Senate. 2. That with this object it is desirable for the Senate to exercise its power under the present Charter of revising the list of affiliated Colleges, and from time to time of admitting to or excluding from this list according to the position taken by these Colleges at the University examinations for degrees, and on such other grounds as the Senate may in each case determine. 3. That it would be desirable that the educating bodies included in the revised list should be invited to communicate, by delegates or in writing, with the Senate, and that facilities should be afforded to such delegates of deliberating together and of communicating with the Senate, especially on the subject of examinations. 4. That it is desirable for the examiners of the University, either in faculties or collectively, to form a Board, one of whose functions would be to consider and report upon any subject connected with the examinations which they might deem of importance to the University. 5. That it is desirable that the University should take advantage of such opportunities as may present themselves of promoting, by the institution of University chairs, or otherwise, the cultivation of such higher or less usual branches of study as can be more conveniently or more efficiently taught by a central body. 6. That it is desirable for the Senate to consider the importance of recognising independent research in the examinations for the higher degrees in such way as the senate may approve.

M. Bardoux has sent to the French Chamber of Deputies a project for establishing in Algiers *écoles préparatoires* of science, letters, and law, in order to organise in the colony superior teaching. The expenses are estimated at one-and-a-half million of francs. An *école préparatoire* of medicine was established eighteen years ago.

The late Prof. Wilhelm Pütz, well known through his excellent geographical and historical hand-books, has bequeathed the sum of 115,000 reichsmark (5,750*l.*) to the University of Bonn, with the stipulation that it is to be employed for furthering the eaching of geography and history.

[1] This extended and carefully made series are prepared for publication; we cannot too highly estimate this valuable contribution to magnetical science.

SCIENTIFIC SERIALS

American Journal of Science and Arts, April.—In this number Prof. Hastings records observations which prove that the variation in dispersive power of glass, attending variation in temperature, is relatively enormously greater than that in the refractive power. This could hardly have before escaped notice, but for a singular relation in the co-efficients, in virtue of which, probably, an achromatic combination for one temperature is good for all others within moderate limits.—Prof. Rowland has made a new determination of the absolute unit of electrical resistance, his method being to induce a current in a closed circuit by reversal of the main current. He finds the B.A. unit too great by about ·88 per cent. A difference of nearly 3 per cent. between his result and that of Kohlrausch he endeavours to explain from a criticism of the latter's method, pointing out what he thinks its defects.—Prof. Langley differs from M. Janssen as to the ultimate form of the "grains" in the solar photosphere, regarding them as the ends of filaments (a simile he employs is that of a bird's-eye view of a field of grain acted on by wind), whilst M. Janssen thinks them literal spheres.—In the projection of microscope photographs, Prof. Draper increases the brilliancy of the result by removing the supporting stage of the slide further from the condenser so that a convergent beam of light may fall on the object.—Several papers in this number deal with points in American geology and physiography; the surface geology of South-West Pennsylvania, the driftless interior of North America, the ancient outlet of the Great Salt Lake, Lower Silurian fossils in Pennsylvanian limestone, intrusive nature of the triassic trap-sheets of New Jersey, &c. A tree-like fossil plant, *Glyptodendron*, lately found in the Upper Silurian rocks of Ohio is described by Prof. Claypole as (from its position) possessing a peculiar interest.

Annalen der Physik und Chemie, No. 3, 1878.—M. Röntgen here describes experiments which seem to invalidate results obtained by Wilhelmy in 1863 and 1864 regarding the condensation of fluids on the surface of solid bodies. He finds the difference of the two surface tensions, caoutchouc-air and caoutchouc-water, to be about 8·0 mg. per millimetre, when both have attained their normal value (which does not occur immediately after contact).—It is shown by M. Claes that for extremely dilute solutions of a substance with absorption-bands, the position of these bands may considerably vary, and a band is absolutely characterised by that wave-length which belongs to it in solution in solvents that are without dispersion.—In a paper on quantitative spectrum analysis, M. Vierordt investigates the influence of narrowing of the entrance-slit on colour-tone and brightness; by adapting four movable plates to the slit he has been able accurately to fix the amount of error in his determinations of intensity of light with his spectral photometer, and show that throughout the spectrum they are very small, and may mostly be neglected. In every case, however, they can be fully corrected by arrangements he describes.—M. Lommel advances a theory of normal and anomalous dispersion, and M. Fröhlich applies the principle of conservation of energy to the phenomena of diffraction.—The temperature-surface of water vapour is treated by M. Ritter.

SOCIETIES AND ACADEMIES

London

Royal Society, April 4.—"On the Determination of the Constants of the Cup Anemometer by Experiments with a Whirling Machine," by T. R. Robinson, D.D., F.R.S.

In his description of the cup anemometer (*Trans.* R. I. Academy, vol. xxii.), Dr. Robinson had inferred from experiments on a very limited scale with Robins whirling machine that the limiting ratio of the wind's velocity to that of the centres of the cups = 3. Recent experiments by M. Dohrandt have shown that this number is too great. As some of the details of M. Dohrandt's experiments appeared objectionable, and as all the data necessary for determining the constants were not given, it seemed desirable to repeat them.

After describing the apparatus used, and the locality where it was erected, he explains the forces which act on an anemometer. When these balance each other through a revolution, the condition of permanent motion is expressed by the equation $aV^2 - 2\beta Vv - \gamma v^2 - F = 0$. Where V and v are the velocities of the wind and anemometer in miles per hour, F the momentum of the friction, at the centres of the cups, in grains, the coefficients α, β, γ, cannot be found *à priori* in the present state of hydrodynamics; but if they be constant, or vary but little as v changes, they can be found, at least approximately, by combining several equations in which $V v F$ are known. Unfortunately this method has serious difficulties. We cannot produce wind of a known V, and must substitute for it the transport of the anemometer through the air at a known speed. But the rotation of the whirling machine produces an air vortex of considerable power, whose motion must be subtracted from that of the machine. If this motion were uniform it would do no harm, but it is found to be so very irregular that the V which must be used is uncertain.

The determination of F was also uncertain in these experiments, chiefly because the locality where the apparatus was erected (though the best which he could obtain) was affected by tremors by the action of adjacent machinery which made the frictions variable. Five anemometers were tried. No. 1 with 9-inch cups and 24-inch arms, the Kew type; No. 2, the same arms, but 4-inch cups; No. 3, with 9-inch cups and 12-inch arms; No. 4, the same 12-inch arms and 4-inch cups; and No. 5, semi-cylinder cups 9 inches square and 24-inch arms. Of these the small cups gave unsatisfactory results, the cylinders (to his surprise) the best; the 9-inch were sufficiently good to authorise the following conclusions, observing that α was measured directly. It is as the area of the cups, and is independent of the length of the arms, unless they are so short that the wake of one cup interferes with the followers.

1. The equation represents the observations well enough for all practical purposes, while V ranges from 5 to 40, and F from 113 to 3683.

2. It is equally effective if γ be omitted.

3. β and γ are probably proportional to α, and the three are as the density of the air.

4. Admitting this, the specialty of any anemometer depends on $\frac{F}{\alpha}$ only.

5. The ratio of the wind's velocity to that of cups changes with v and F. The highest value in these experiments = 21·58; its least value = 2·32.

6. With the constants which he found for the 9-inch cups, the limit of this ratio, that for V infinite = 2·30 instead of 3·0.

He proposes to verify these conclusions with real wind, and has established No. 1 near one of the Kew type similar to it. By comparing their simultaneous v under different frictions, he will obtain equations which, assuming α as known, will, he hopes, give β and γ far more certainly.

Mathematical Society, May 9.—Lord Rayleigh, F.R.S., president, in the chair.—Messrs. Wm. Hicks and T. R. Terry were elected members, and Prof. Minchin was admitted into the Society. Messrs. Brioschi, Darboux, Gordan, Sophus Lie, and Mannheim, were elected honorary foreign members.—Prof. Henrici, F.R.S., communicated a paper by Dr. Klein, of Munich, "Ueber die Transformation der elliptischen Functionen."—Prof. Cayley, F.R.S., spoke on the theory of groups.—Prof. Kennedy read his notes on the solution of statical problems connected with linkworks and other plane mechanisms. The special object of this last paper was to give an elementary solution of the problem: given a linkwork or plane mechanism of any number of links, with any force acting on any one of them, find the magnitude of the force necessary to balance the mechanism of acting in any direction on any other link. The method employed was the replacement of the two links on which the forces acted by two others which had the same instantaneous centres and the same angular-velocity ratio, but which were so chosen that they could be directly connected together by a third link. In this way a simple combination of the links was used as a "virtual mechanism" to replace the original complex linkwork, and the solution became extremely simple. Incidentally the author took occasion to insist on the advantages of the consistent use of the notion of the instantaneous centre even in the most elementary treatment of mechanical problems.—Mr. Glaisher, F.R.S., communicated a generalised form of certain series.—Mr. Kempe read a portion of his paper on conjugate four-piece linkages.

Linnean Society, April 18.—Dr. J. Gwyn Jeffreys, F.R.S., vice-president, in the chair.—The Rev. H. H. Higgins exhibited photographs of a large beetle, the *Dynastes neptunus*, Shönherr, and of an undetermined species of locust from Borneo, the latter resembling the genus Pseudophyllus, but measuring 9½ inches in expanse of wings.—A paper on the geographical distribution of the gulls and terns (Laridæ) was read by Mr. Howard Saunders. Notwithstanding the wide marine dispersion of the group, it possesses several remarkable isolated forms. In numbers there are about fifty-three species of terns and skinners, fifty of gulls, and six of Skua gulls. The majority of the typical Laridæ are found in the North Pacific, where alone the Arctic and white primaried forms are connected through *Larus glaucescens* with the group which have distinctly barred primary wing feathers. In the same area can be traced the typical hooded gulls, of which *L. ridibundus* is the Palæarctic representative, and which in *L. glaucoides* reaches unbroken to the Magellan Straits, while in the eastern hemisphere it is not found beyond 10° N. lat. There also obtains the peculiar coloured tern, *Sterna aleutica*, which connects the typical Sternæ with the intertropical sooty-terns, *S. lunata*, *S. anæstheta*, and *S. fuliginosa*. Of isolated groups which have no apparent connection with the Pacific may be mentioned the New Zealand *Larus bulleri* and *L. scopulinus*, the Australian *L. novæ-hollandiæ* and the South African *L. hartlaubi*. In the Arctic region there are two isolated specialised genera of gulls, Pagophila and Rhodostethia, which are not known on the Pacific side, while amongst the terns the intertropical genera, Næmia, Anous, and Gygis, although somewhat related among themselves, offer no particular points of union with the typical Sterninæ. It results that the bulk of the evidence favours the idea of the North Pacific probably being the centre of dispersion of these chiefly oceanic or shore-frequenting birds, the Laridæ.—Mr. R. Irwyn Lynch next made a communication on the mechanism for the fertilisation of *Meyenia erecta*, Benth. This West African acanthaceous shrub has a funnel-shaped corolla with hairy anthers midway in the tube. The longer slender flexible style has its double-lipped stigma so formed and placed that insects alighting and entering towards the nectar at the bottom of the flower on their return, so move the lever-lip of the stigma as to produce pollenisation.—Mr. J. Clark Hawkshaw brought forward some notes on the action of limpets (*Patella*) in sinking pits in, and abrading the surface of the chalk at Dover. The limpet tracks are finely-grooved hollows generally of a zigzag pattern varying from eight to fourteen inches square, and about a line deep; and according to the author produced by the lingual teeth of the animal while grazing on the fine coating of sea-weed which covers the face of the chalk. The grooving deepens as the creatures repeat the process over the same ground; they moreover sink deeper stationary basin-shaped pits, resting-places to which they return after feeding. These latter, he holds, are also formed by mechanical, and not chemical agency, as some contend. Though taken singly, the denudation of the chalk by the limpets is very insignificant, yet taken in the aggregate, the amount annually abraded must be very considerable.—The following gentlemen were balloted for, and duly elected Fellows of the Society:—The Rev. A. A. Harland, the Rev. J. J. Muir, Mr. W. S. Piper, and Mr. Fred. Townsend.

Meteorological Society, April 17.—Mr. C. Greaves, president, in the chair.—Mons. Marié Davy, Capt. N. Hoffmeyer, Prof. D. Ragona, and Dr. A. Wojeikoff, were elected honorary members.—The discussion on waterspouts and globular lightning, which was adjourned from the last meeting, was resumed and concluded.—The following papers were then read:—On the application of harmonic analysis to the reduction of meteorological observations, and on the general methods of meteorology, by the Hon. R. Abercromby, F.M.S. The meaning of the harmonic analysis is first shown, in reference to average barometric pressure, by tracing the geometrical and physical significance of every step from the barogram till the tabulated results are combined in a harmonic series. It is then shown that, whether we regard this series simply as an algebraic embodiment of a fact, or as a series of harmonic components, as suggested by Sir W. Thomson, it is simply a method of averages, and our estimate of its value must depend upon an estimate of the use of averages at all in meteorology. It is then pointed out where averages are useful, and their failure to make meteorology an exact science is traced to three causes: (1) That the process of averaging eliminates the variable effects of cyclones and anti-cyclones, on which all weather from day to day depends; and on this are based some general remarks on the use of synoptic charts, not only in explaining and forecasting weather, but in attacking such problems as the influence of changes of the distribution of land and water on climates, and the cyclic recurrence of rain or cold. (2) That deductions from averages only give the facts, and not the causes, of any periodic phenomena. The position of diurnal and other periodic variations in the general scheme of meteorology is then pointed out, and it is shown that their causes can only be discovered by careful study of meteorograms from day to day. (3) That in taking averages, phenomena are often classed as identical, which have really not one common property. For instance, rain in this country is associated with at least three different conditions of atmospheric disturbance, and it is necessary to discriminate between these kinds before meteorology can be an exact science.—On some peculiarities in the migration of birds in the autumn and winter of 1877-78, by J. Cordeaux.—Mr. Symons gave a verbal description of the recent heavy fall of rain, on April 10 and 11, the greatest amount known to have been registered being 4·6 inches at Haverstock Hill.

Royal Microscopical Society, April 3.—Mr. H. J. Slack, president, in the chair.—A paper was read by Mr. J. W. Stephenson on a new immersion object-glass which had been designed by him to obviate the difficulty often experienced in the accurate arrangement of the adjusting collars of high-angled objectives. This new glass had a focal distance of $\frac{1}{8}$ and a balsam angle of 113°; it was stated to bear very deep eye-pieces and to have a very flat field. The great difficulty of obtaining an "immersion" fluid having the same refractive index as crown glass had at length been overcome by the adoption of oil of cedar wood diluted with $\frac{1}{4}$ part of oil of fennel seeds. The objective was exhibited in the room at the close of the meeting.—A paper was read by Mr. Frank Crisp on the present condition of microscopy in England, in which, as regarded a knowledge of the optical and mathematical principles of the instrument, unfavourable comparisons were drawn between the workers at home and abroad, and a greater degree of attention to the construction of the various portions of the instrument was urged upon English microscopists.—After the meeting Dr. Millar exhibited a small piece of a very beautiful sponge, *Acarnus innominatus*, Gray, Mr. Curties some stained vegetable tissues, and Prof. Cleve some diatoms mounted to illustrate his pamphlet.

Geological Society, April 3.—Henry Clifton Sorby, F.R.S., president, in the chair.—Rev. Albert Augustus Harland, M.A., F.S.A., and Thomas William Shore, were elected Fellows of the Society.—The following communications were read:—On an unconformable break at the base of the Cambrian Rocks near Llanberis, by George Maw, F.L.S., F.G.S.—On the so-called greenstones of Central and Eastern Cornwall, by J. Arthur Phillips, F.G.S.—The recession of the falls of St. Anthony, by N. H. Winchell, communicated by J. Geikie, F.R.S., F.G.S.

PARIS

Academy of Sciences, May 6.—M. Fizeau in the chair.—The death of M. Malaguti, correspondent in chemistry, was commented on by M. Dumas.—The following among other papers were read:—Experiments on the heat which may have been developed by mechanical actions in rocks, especially clays; and deductions regarding metamorphism, &c. (continued), by M. Daubrée. He rotated rapidly a circular marble plate on a vertical axis, and applied to a small part of its surface, near the circumference, a small weighted and fixed marble plate, measuring the rise of temperature of the latter with an alcohol thermometer. In one minute, with 445 revolutions, there was an increase of 4·5°. Dry clay was also heated by friction on limestone, &c. Apart from all eruptive rocks, the transformation of rocks and appearance of new mineral species may be caused by mechanical actions in the rocks transformed.—On a new memoir by M. Bertin. Observations on rolling and pitching with the double oscillograph, on board various ships, by M. Dupuy de Lome. *Inter alia*, it is shown that the duration of rolls varies a little (for the same vessel) with the intensity of the wind, and (contrary to what one might at first think) the rolls executed against the wind are always considerably shorter than those in the opposite direction.—M. Chauveau was elected correspondent in medicine and surgery, in room of the late M. Gintrac.—Researches proving the non-necessity of intercrossing of the conductors serving for voluntary movements at the base of the brain, or elsewhere, by M. Brown-Sequard. Two series of arguments are adduced to prove that these conductors do not intercross in the rachidian bulb nor in the protuberance; hence the inference stated.—On the mechanism and use of a differential counter, by M. Valessie. This instrument gives precise indications for regulating the average velocity and working of a machine; it is used in several French ironclads. Its principal part is a second watch, the case of which turns, by the action of the engine, in the opposite direction to that of the needle.—On the impossibility of propagation of persistent longitudinal waves in ether, free or engaged, in a transparent body, by M. Pellat. This demonstration is based (1) on the fact that the reflection at the surface of an isotropous transparent body, under Brewsterian incidence, extinguishes almost completely a ray polarised in the perpendicular plane; (2) on the principle of conservation of energy applied to such reflection, supposing it takes place according to Cauchy's formulæ.—On the telegraphic employment of the telephone, by M. Gressier. He distinguishes two kinds of disturbing sounds—that arising from induction by currents in neighbouring wires, and a very confused noise (heard most at night and accompanied with deflection of the galvanometer), which he thinks due to the wire passing in different places through air layers which undergo rapid and considerable variations in potential, producing various currents. This suggested a means of studying variations in atmospheric electricity. M. Du Moncel pointed out that these latter currents had been studied with the galvanometer.—On the crystallisation of silica by the dry process, by M. Hautefeuille. Alkaline tungstates may with advantage be used instead of phosphates (as used by M. Rose), for they render obtainable at will, crystallised silica, either in the trydimite or quartz form.—On the gold method and the termination of the nerves in unstriated muscle, by M. Ranvier. As in striated muscle, these nerves end with an arborised expansion of the cylinder axis on the surface of the muscle-elements. In contraction an organ co-operates which is not under the direct action of the nerve-centres.—Action of morphine on dogs, by M. Picard. The vascular dilatation and contraction of the pupil result from paresis of the sympathetic nerve.—On Wartelia, a new genus of annelids considered wrongly as embryos of Terebella, by M. Giard.—On the malacological fauna of New Guinea, by M. Tapparone-Canefoi. This belongs quite to the great fauna of the Indo-Pacific region.—Soda in plants, by M. Contejean. More than three-fourths of terrestrial plants (not maritime) belonging to regions not apparently saline contain soda; it is mostly in the subterranean portion. Aquatic plants have it in all their submerged parts. The aptitude for soda varies according to family, species, &c.

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